BACK TO MARS: NASA SCOUTS TWO NEW LOCATIONS

AIR&SPACE

Smithsonian

JANUARY 2004

INSIDE

A Preview of Flight in 2103—The Next 100 Years

MORE MUSEUM

THE STEVEN F. UDVAR-HAZY CENTER OPENS—WITH MORE SPACE (AND AIR)!

Photo courtesy of Polly Usher

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We found our best watch in a history book

In 1922, a small watchmaker in Switzerland patented the first automatic watch to display the day, month and date. Only 7 of these magnificent timepieces were ever made and this watch was almost lost to history. Today, they are so rare that one original chronograph watch would probably fetch more than $300,000 at auction.

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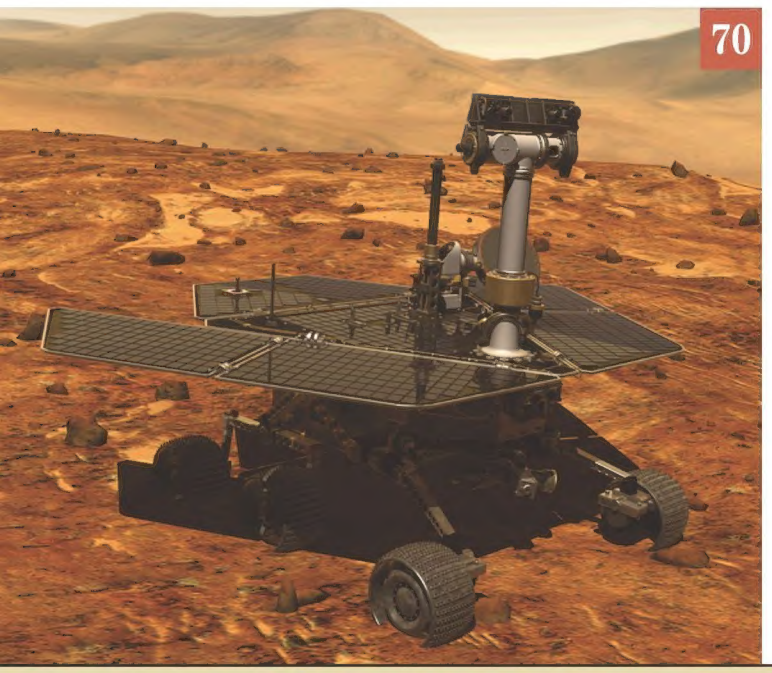


AIR&SPACE

Smithsonian

December 2003/January 2004 ✳ Volume 18 • Number 5

PAGE 35 SPECIAL SUPPLEMENT:
The Steven F. Udvar-Hazy Center
Straight from the National Air and Space Museum, the story of how the Udvar-Hazy Center came to be and what you will find there when you visit.

FEATURES

43 MAGAZINE WITHIN A MAGAZINE

Air & Space/Smithsonian | December 2103
Celebrating 200 Years of Flight.
Illustrations by Paul DiMare

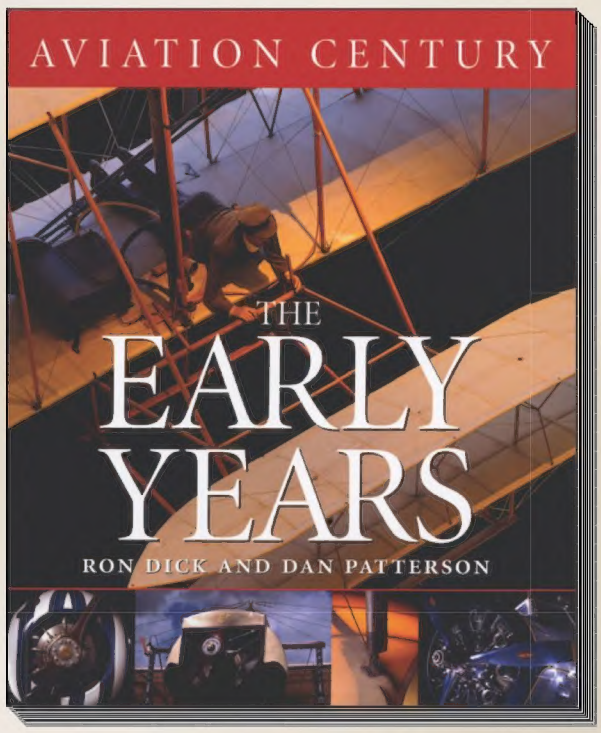
On the 100th anniversary of the airplane's invention, we look ahead to the next centennial to find where flight will take us. In an issue of Air & Space *a hundred years from now, you'll read about*

- *offshore airports,*
- *Mach 10 airliners,*
- *personal air vehicles,*
- *and a brand-new reason for exploring space.*

Cover: *In the airliner sweeping through Dane Penland's twilit scene, the captain has just said, "On the right, a view of the National Air and Space Museum's new Steven F. Udvar-Hazy Center."*

DEPARTMENTS

DOCUMENTING THE CENTURY



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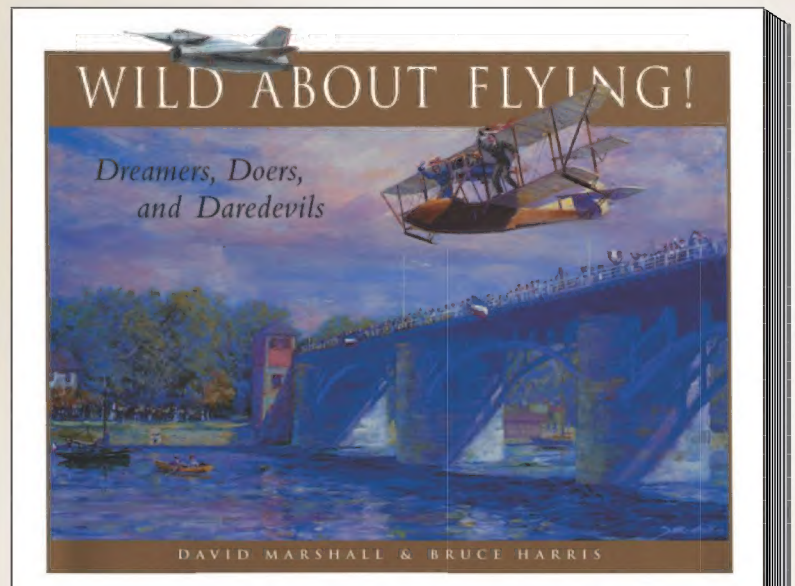
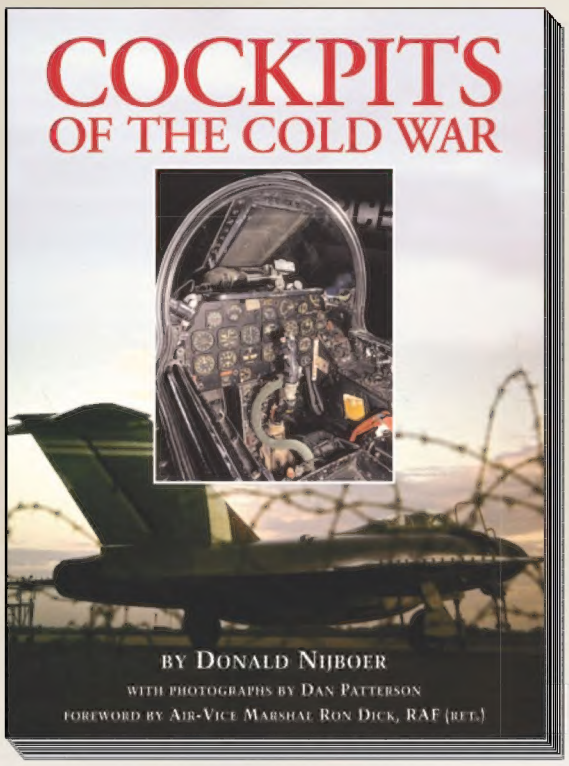


COCKPITS OF THE COLD WAR



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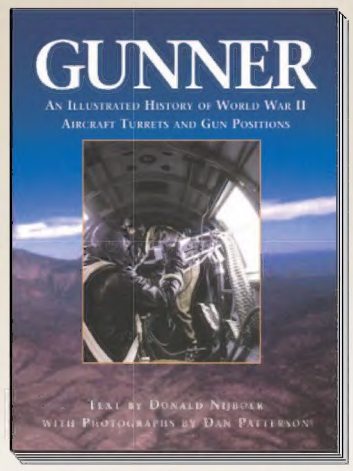

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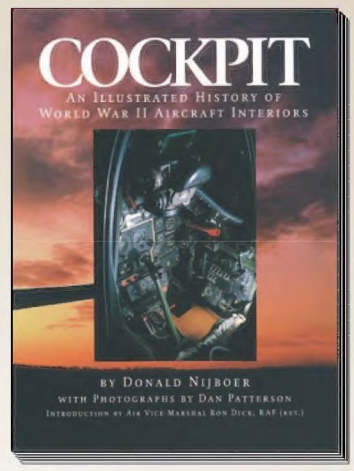

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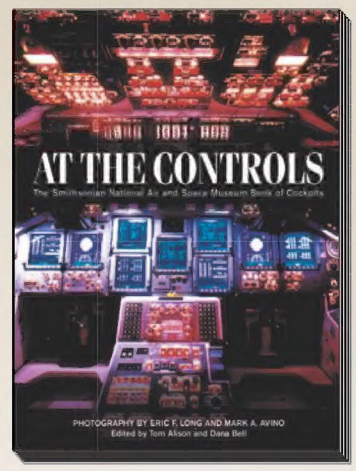

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Fast Forward

In 1901, most people were skeptical that a piloted, heavier-than-air flying machine could be developed, and the few would-be inventors at work on the idea were thought of as madmen. Some scientists and engineers even showed mathematically that such a flight was impossible. Simon Newcomb, a respected physicist and astronomer, wrote in 1901 that "the first successful flyer would be the handiwork of a watchmaker, and carry nothing heavier than an insect." Wilbur Wright confessed in a dinner speech years afterward that in 1901 he had told his brother that "man will never fly for fifty years."

All of them were wrong, of course. Now, after a century of exponential progress, we are once again trying to assess what the future of aeronautics holds—and we may get it just as wrong as they did back in 1901. We may know a lot about the engineering, science, and design methodology that underlie modern airplanes, but we could fall into the trap of simply extending current trends and concluding that advances will be small and incremental.

Real innovators already see airplane configurations that can double or triple current lift-to-drag ratios, the measure of aerodynamic efficiency. They envision new propulsion concepts and fuels. They forecast design driven by information technology and structures created at the atomic and molecular levels, or nanotechnology. Some predict a huge market for personal aircraft, akin to the "airplane in every garage" scenarios of the past.

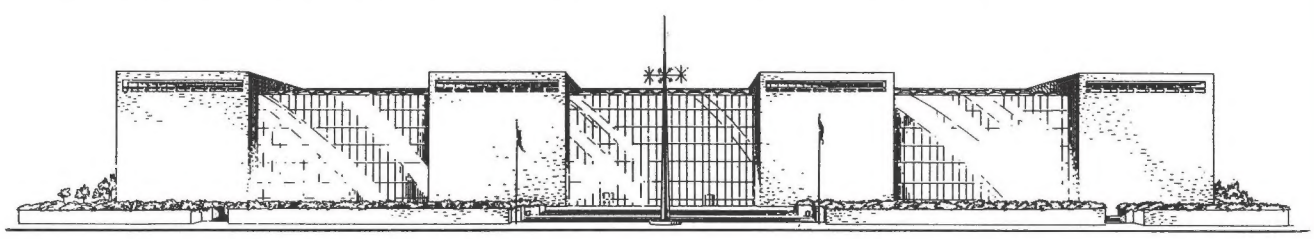
Flight during the 20th century was driven by the quest for speed, altitude, and distance. Today we add economy, environmental acceptability, and convenience to the list. Safety and reliability have always been of paramount importance, but these too will improve. Current technology is simply a platform from which to leap to new advances.

We can be confident that travel will continue to drive the urge to go farther, faster, and higher, and that urge can only be satisfied by aircraft. We'll find a solution to the sonic boom problem, thereby allowing supersonic flight over land. Engine noise and emissions will be reduced, and we'll have environmentally acceptable and economically feasible—even profitable—supersonic transports. Hypersonic flight is the final frontier, and the 21st century will witness the advent of successful hypersonic atmospheric vehicles for both military and civilian missions.

Ironically, after the Wright brothers worked so hard to put a human being in the air, aeronautical engineers will continue working to eliminate the pilot. When we remove the pilot, the designers' options for the airplane open up considerably, allowing greater acceleration, more maneuverability, lower weight, and much more aggressive tactics in the air.

We may not be much more accurate at predicting the future of flight than the naysayers of 1901 were. But we do have the advantage of looking back over the last hundred years of flight and extrapolating from what we've already accomplished. We just need to remember to multiply everything by ten.

—J.R. Dailey is the director of the National Air and Space Museum.



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LETTERS

Two Lives for a Tri-Motor

I was delighted to see that the cover of the Aug./Sept. 2003 issue had a photo of Stinson Tri-motor NC-11153. My grandfather, Pierce "Scotty" Carroll, used to own that airplane. He flew it for sightseeing customers over Chicago's lakefront during the 1930s. I'd often seen family photos of this Tri-motor over Chicago.

When I heard about the re-created

COURTESY CHRISTOPHER LYNCH

Our Aug./Sept. cover star in its youth, hosting sightseers over Chicago.

National Air Tour ("The Magical History Tour," Aug./Sept. 2003), I showed up for the September 7 stop in Lansing, Illinois. That day, the Stinson literally flew into my life. While waiting for the tour to arrive, I looked up and saw a brilliant blue Tri-motor a thousand feet in the air. After turning into Lansing's flight pattern, the plane began its final approach, but not before it buzzed the field, its throttle open, roaring past the excited crowd. When I saw that it had the tail number of my grandfather's plane, I cheered.

When the plane landed, I got a chance to examine it up close, along with my daughters and my three-year-old son, Pierce, who is named after the great-grandfather who flew it.

So thanks to Greg Herrick for bringing the National Air Tour back from history, and for making an old photograph come to life.

Christopher Lynch
Chicago, Illlinois

Of Caribou, Hueys, and Chinooks

Having served in Vietnam with the First Air Cavalry in 1966 and '67, I am pleased to see Army aircraft from that era still kickin' up dust ["Air(show) Assault," Oct./Nov. 2003]. However, I was a flight engineer on the Cavalry's workhorse, the CH-47 A-model Chinook, an aircraft your story neither showed nor mentioned.

On television, the rotory-wing symbol of the Vietnam war was the Huey, but the Chinooks flew every type of mission, and added a heavy-lift capability.

Paul Silva
Albuquerque, New Mexico

Editors' reply: Actually, we did show a Chinook, though inadvertently. As a dozen or so readers pointed out, the photograph on page 27 shows the interior of a Chinook, not, as stated, a Caribou. The photo was taken in Campbell, Kentucky, at the 2002 "Week of Eagles," an annual reunion of the 101st Airborne Division. As the article stated, the Army Aviation Heritage Foundation does not have a Chinook. We regret the error.

Author Shelby Spires states that Caribou 62-4149 is "the only Caribou still flying in the Western hemisphere." I'm not entirely sure that is correct. I joined de Havilland too late to work on the Caribou, but I installed the flight controls on its later brother, the Buffalo, and very infrequently during that time, I have seen the odd Caribou come into our flightline. And last September 25, at the 75th anniversary celebrations of de Havilland, a Caribou with PT-6 turbine engines was on display (the turbine conversion had been done by Ten-Turbo in New Jersey). This Caribou has also been an occasional visitor.

Mel Goddard
Brampton, Ontario, Canada

Make Mine a Boeing

Is Bill Sweetman, the author of "The Contender" (Oct./Nov. 2003), a sales rep for Airbus? He glossed over every significant Airbus problem and safety-related incident and ignored the causes completely. He made it sound as if Airbus has never made any mistakes and that its aircraft are without peer. The truth (to me) is far from that. I've followed the company's history of aircraft problems (like the tail that fell off recently). In addition, the pilots are never in control because of Airbus' fly-by-wire systems, which leave decisions to computers. Regardless of the circumstances, I would never fly Airbus again.

As much as I like *Air & Space*, I was so incensed by this article that if I see another like it, I will cancel my subscription.

Clark S. Robbins
White Lake, Michigan

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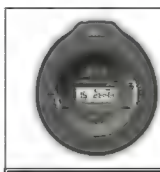

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Bill Sweetman short-changes the government subsidy issue. Airbus deliberately hides its massive government subsidies, in part to hide from U.S. anti-dumping laws. Boeing receives no such subsidy from the U.S. government. Sweetman's assertion that Boeing does receive a U.S. government subsidy because it sells military hardware to the government is misleading at best. As an innovative company, Boeing invests some of its profits (and some of this money is from sales to the U.S. government) into research and development. You also fail to report that the French, British, and German governments heavily pressure domestic airlines to "buy Airbus." Without these subsidies and pressure, Airbus would have been a memory.

Bob Toxen
Atlanta, Georgia

Put That Elephant to Work

Why not use the Buran ("White Elephant," Dec. 2002/Jan. 2003) as the escape vehicle for the International Space Station? It is already built, and it has proven, in its only flight, that it can land safely without a pilot. The two Energia rockets going to waste in Russia could instead be taking the Buran to the station.

Such use would be a more fitting tribute to this Russian achievement than making it into a kiddie ride.

Brian Jolliff
Kansas City, Missouri

Spins: Don't Even Go There

As a Class 3 flight instructor in Canada, I have taught spin awareness and training to pilots at many different levels. After reading "The Spin Debate" (Oct./Nov. 2003), I see no logic to the rationale given for not teaching spin awareness or spin training. I have never taught spins solely for the purpose of recovery; that makes no sense. Author Joseph Bourque is correct to state that in the flight realm in which a spin is most likely—low and slow—it would be almost impossible to recover.

Spin training does not start with spins; it starts with the instructor transferring a mindset of safety to the student before flying ever begins. I believe in spin training including three processes: Recognize, Avoid, and Recover. If I do my job right, my students should never have to employ the third.

The pilot who spins in at 400 feet dies not because he doesn't recover—he dies because he never recognized the signs that warned of the spin and thus did not do what was necessary to prevent it from happening.

The Federal Aviation Administration notes that modern aircraft are more spin-resistant, but they are not spin-proof. A 747 pilot is not paid to program an auto-pilot to fly to a destination and use auto-land; a 10-year-old could be taught to do that. Pilots are paid for skill and professionalism—for knowing what to do when all is not right, for recognizing, avoiding, and, if necessary, recovering from those situations that are dangerous to their passengers.

Brett MacNeil
Antigonish, Nova Scotia, Canada

The Lunar Secrets of Jackson, Michigan

In the Feb./Mar. 2003 Letters section, Robert J. Fowler complains of not being able to find the stereoscopic photographs of rocks taken on the moon with Tommy Gold's camera ("Shooting the Moon," Apr./May 2002). I recently visited the Michigan Space Center, in Jackson, and saw four lunar photos available for viewing with 3-D glasses.

Matt Winger
via e-mail

Dude, Where's Your Judgment?

The intended humor of "Dude, Where's My Airplane?" (Flights & Fancy, Oct./Nov. 2003) is lost when one realizes the stupidity of hand-propping an engine without an operator at the airplane's controls (a practice in violation of Federal Aviation Regulations).

I was employed by Aeronca and assisted in constructing the prototype of the Champ. It is out of character for your outstanding publication to belittle a classic aircraft.

Bob Hollenbaugh
Middletown, Ohio

To single the Aeronca out is unfair, but to make a joke of Aeronca technical advisor Bill Pancake's name is even worse. Mr. Pancake is one of the finest, most selfless, and most giving persons I have had the pleasure to meet. His contributions of time and energy have increased the safety of countless flights over the years. Mr. Pancake has given out his home phone number freely, even to people in other countries, so he can give advice to anyone who needs it. For your author to make fun of the man's name is shameful.

David Lindeman
via e-mail

Editors' reply: Many Aeronca owners told us that they didn't see the humor in our piece. We might have caused less offense had we included the explanation for the Aeronca's ability to cover such long distances once it makes a break for freedom.

The Champ has been endowed with generous dihedral, which makes the airplane exceptionally stable and able to fly in a straight line without human guidance. (Champ owners point out that other lightplanes that take off on their own after hand-propping seldom make it very far from the ramp.) In any case, it's not the airplane's fault when one gets away, of course; it's the pilot's, and we apologize for not making that clearer.

We also regret publishing a cheap shot at Bill Pancake's name, and for any other anguish the piece caused.

Corrections

Oct./Nov. 2003 "Backgrounder: State of the Station": The array of solar panels will generate 100 kilowatts, not 100,000.

"The Spin Debate": The "Surviving a Spin" illustration neglected to point out that after pullout, the throttle should be advanced.

"Air(show) Assault": (1) The folding-fin aerial rockets carried by the AH-1G Cobra are 2.75 inches, not millimeters, in diameter. (2) The helicopters shown on the television series "M*A*S*H" were Bell OH-13 Sioux, not Hiller OH-23D Ravens.

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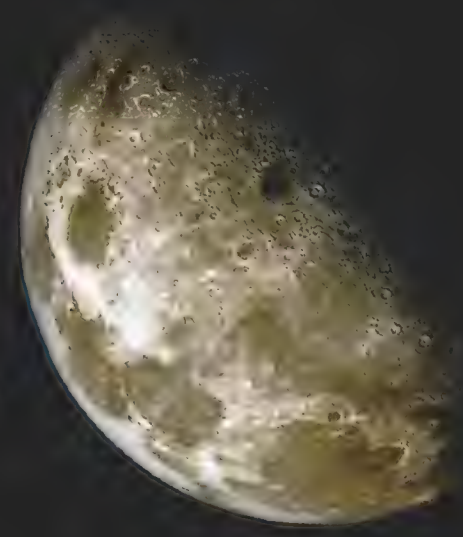

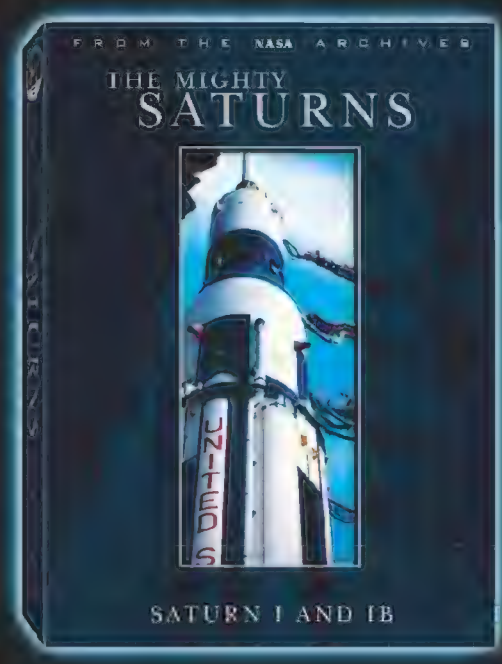

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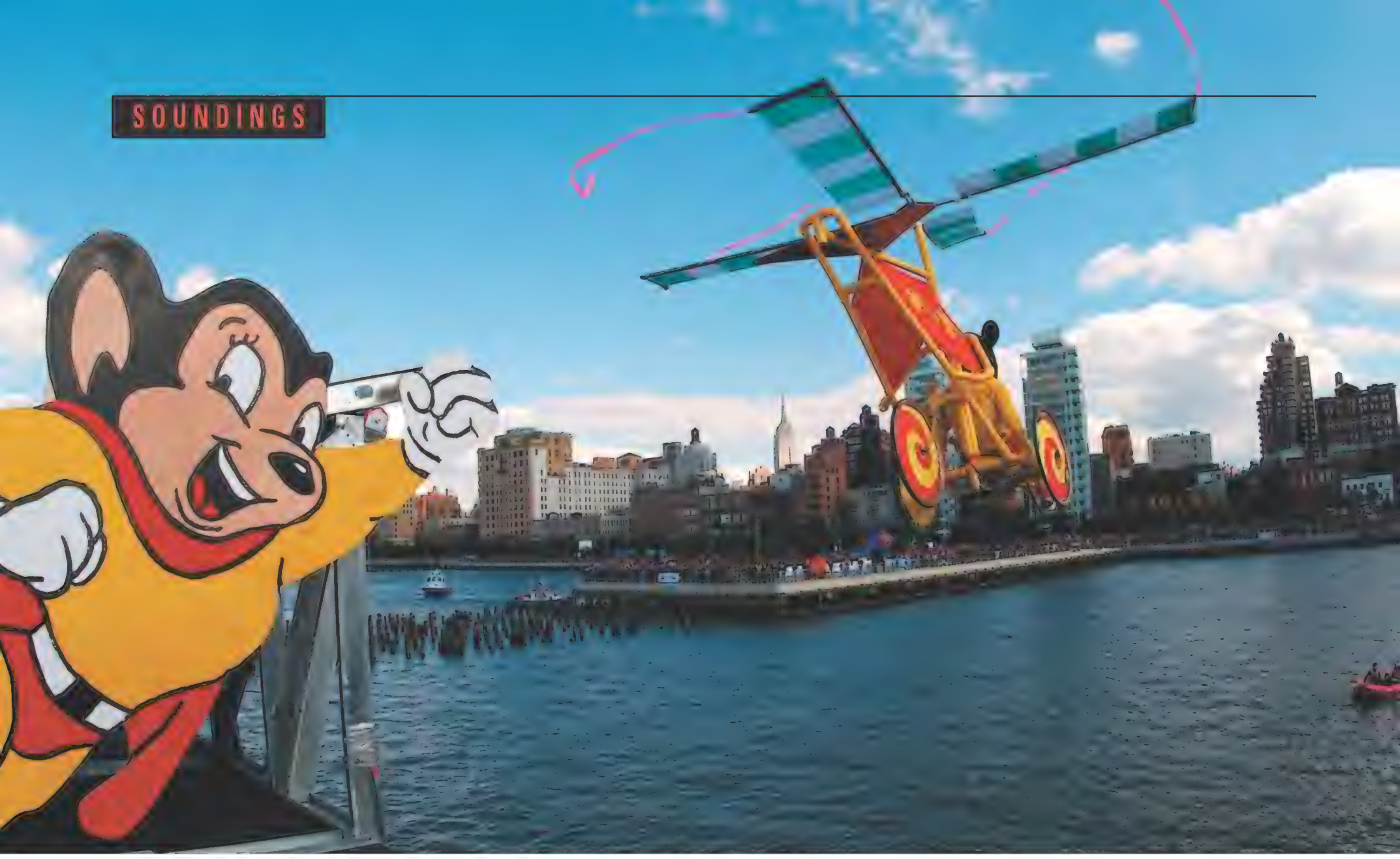


Into the Drink, Junior Birdman

With a flight of 36 feet, the *faux*-rotary-wing *Mighty Whirl* grabbed the lead early. For a while the closest assault on *Whirl*'s primacy came from a bunch of aviating cavemen. "We're going to fly around the Statue of Liberty and come back and land," vowed one hirsute *Homo sapien* before their machine, *Superfunkadactyl*, got airborne. But the best it could manage was a slide off the ramp into 65-degree water. A few blamed the tailwind. No one admitted that the fault might lie in the aircraft's design, which was based on the aerodynamics of the pterodactyl.

Last October, some 40,000 people turned out for New York City's Red Bull Flugtag, a five-hour competition among three dozen teams to see which machine could plunge from a 30-foot-high launch ramp into the Hudson River with the greatest flair. Flugtag, German for "flying day," originated in Vienna in 1991 with Dietrich Mateschitz, founder of the energy-drink company Red Bull. This was the world's 27th Flugtag, and New York's first. Despite the chaos inherent in "flying" grand pianos, blenders, and a can of Homer Simpson's favorite beer, Duff, into the river, there were rules: Each craft had to be human-powered, its crew could not exceed five, and it had to measure no more than 30 feet wide and weigh 450 pounds max. A panel of five judged each team on distance traveled, creativity, and showmanship.

To bolster their scores, all the teams performed brief skits before launch. The Flying Mozarts waltzed around their styrofoam baby grand, while the Duff Beer men donned New York Yankees jerseys, which they ripped off to reveal T-shirts bearing the Boston Red Sox logo. Both craft plunged straight down, followed by their crews.

Mike Raab, commander of the winged *Submarine #2*, vowed to fly as far as Hudson Street. Tony Abusio, pilot of *Big Paper Airplane*, planned to make it all the way across town to the West Side Highway. Costumed as Ozzie Osbourne, he lost his long black wig but stayed dry by clinging to *Big Paper Airplane*'s top as it belly-flopped into the Hudson. (Police dragged all flying-machines-turned-rafts to a garbage barge.)

Meanwhile, *Mighty Whirl*, piloted by Mighty Mouse, held fast to the lead with 56 points. Then came *Pedal Power*, the most aerodynamic-looking craft, built by a group of Pennsylvania high school students led by teacher Kirk Marshall. Following a lame team skit, Marshall hopped on and pedaled *Pedal Power* 39 feet past the ramp edge. It wasn't the U.S. record (70 feet) and nowhere near the world record (195 feet). But it was enough to put the team in the lead, with 61 points. In the end, Flintstone-themed *Ballistic Bedrock* edged out *Superfunkadactyl* for third prize (skydiving lessons). *Mighty Whirl* took second (paraglider lessons), and *Pedal Power* won first: flying lessons—something all the contestants could have used, as well as a crash course in aircraft design.

—Phil Scott

Mighty Whirl soared a glorious 36 feet off the launch ramp and proceeded directly into the Hudson River—as did all entrants—at Flugtag New York City last October.

Another Small Step

NASA bigwigs, including Administrator Sean O'Keefe, Mars program managers, and dozens of astronauts, were among the guests at the October opening of a $100 million space simulator, Mission: Space, at Florida's Disney World.

The ride is not for the faint-hearted, the nausea-prone, or the pregnant. The simulator, in reality a giant centrifuge, subjects passengers to a sustained force equal to nearly two Gs—almost two times your body weight. For many, it's no joy ride. After an early-morning, pre-breakfast blastoff, a woman running a nearby cappuccino stand said, "A lot of people don't look so good after the ride. That's why I'm not going on it."

But to Robert "Hoot" Gibson, who last rode a shuttle in 1995, or Charlie Bolden, a retired shuttle commander, or Bob Crippen, a former Kennedy Space Center director and astronaut, the Disney ride barely ticks up the heart rate. "It gives you the sensation of liftoff as the G-forces build up," says Bolden. "It's pretty realistic."

The ride takes groups of four—you're assigned to be commander, pilot, navigator, or engineer—on a virtual trip to Mars. To get there, you take a (scientifically unjustifiable) swing around the moon to pick up a gravity boost, which if nothing else is a good excuse to crank up the centrifuge again. There's the inevitable emergency en route and the not-so-picture-perfect touchdown. The flyover of the Red Planet, based on satellite imagery from Mars Global Surveyor and Mars Odyssey, is spectacular (no sign of the ill-fated Polar Lander or Climate Orbiter probes, though you do get a quick glimpse of the International Space Station and the Hubble Space Telescope as you leave Earth orbit).

NASA presented the ride as an opportunity to educate people about spaceflight. But the opening coincided with the agency's announcement that it is grounding its remaining shuttles until at least September 2004, and China's announcement of its first manned launch.

"When I joined NASA in 1980," said Bolden, "I never would have believed that at the beginning of the 21st century, for the average Joe to experience spaceflight, you have to come to Epcot Center. It's hard to imagine that 42 years after the first human spaceflights, this is where we'd be."

—Irene Mona Klotz

Disney's Mission: Space sends riders out of this world.

DISNEY

RED BULL/CHRISTIAN PONDELLA © 2003

MADE IN MOSCOW

Flying Tractor

When Oregon entrepreneur and pilot Glen Gordon decided to manufacture and sell an airplane, Russia wasn't even on the horizon as a site to build it. But over the last few years, Gordon and engineers from a young company at the Khrunichev space center in Moscow have struck up a partnership. The result is the Russian-built Sherpa, dubbed a "flying tractor," which has 42-inch Chevy truck tires, lands in plowed fields, and can haul over a ton.

Gordon says he was warned not to do business in Russia: "You'll get over there and the Russians will steal your project," his friends told him. So he was wary when representatives from Khrunichev-Aviatekhnika asked if they could photograph the prototype Sherpa he was demonstrating at the 1998 Oshkosh, Wisconsin airshow. But he consented, and the Russians offered to manufacture his flying tractor—in Moscow.

SHERPA WORLDWIDE

The new Sherpa bush plane is equipped with 42-inch Chevy truck tires for sure-footed landings.

It took some convincing, but Gordon and his partner, Byron Root, the Sherpa's chief designer and a northwest U.S. bush pilot, agreed to the Russians' proposal after a tour of their factory demonstrated that it was ideally equipped to produce the aircraft. A team of aeronautical engineers began work three years ago at the Khrunichev plant in western Moscow, where the Soviets made spyplanes and bombers in the 1930s through the '50s, churned out rockets and ballistic missiles during the cold war, and built the space station Mir in the 1980s.

The first few Sherpas were shipped as kits to the United States in July in time for Oshkosh 2003, and three versions are now for sale. The bushplane is made for everything from hauling gold from Siberian mines to emergency medical flights. (One model has room for two gurneys plus medics.) The five-seat T-411 sells for as little as $90,000, while the 10-seat C-700T can cost $895,000—both excluding engine. All models, which take their name from the Mongolian guides who trek the Himalayas burdened with heavy packs, can take off and land in as little as 300 feet.

If U.S. sales are successful, Gordon says he will make Khrunichev-Aviatekhnika full partners in the company, which will then launch a Moscow-based business to market the Sherpa in Russia. Yuri Pervushin, director general of Khrunichev-Aviatekhnika, is hopeful, but he uses the Russian equivalent of "Don't count your chickens" to urge caution: They are not going to "divvy up the fur of an unkilled bear," he says.

Gordon's eyes light up when he talks about the friendships he has forged with the Russian engineers during his seven trips to Moscow. And he lauds their clever design innovations: "The wing is a work of art." Gordon and Root have high hopes not only for the flying tractor but also for Russia's capitalist future. "It'll come," Root says. "A few scars, burns, and scrapes, and they'll get there."

—J. Quinn Martin

Hats Off

Sikorsky Black Hawks, under the watchful eye of a pair of Bell Cobra attack helicopters hovering overhead, come in to pick up a team of commandos who have marked enemy targets in a hostile area. When the special forces are out of harm's way, the Cobras launch missiles, which race across the desert sky and hit the targets, creating an orange fireball. Two Boeing Apache helicopters attack another target with their 30-mm cannon, spitting spent shell casings. The final attack is a bombing run by a formation of camouflaged F-16s and

upgraded F-4s. With a deafening roar, the aircraft fly overhead and release countermeasures flares as they identify their target.

Though the targets are stacks of 55-gallon drums and the bombs are inert water-filled casings, the missile and cannon fire are all real. This is the Israeli air force pilots' graduation ceremony, which was held last June at Hazerim Air Force Base, home of the IAF's flight academy, near the Negev desert city of Beersheva. To the delight of some 5,000 graduates' families and guests, and of course the cadets themselves, the annual private airshow is the IAF's tribute to the newest members of the club. The elite group has passed a rigorous two-year training program; only 10 percent of those who start complete it. After IAF Commander Dan Haloutz presents each graduate with his wings, the new airmen let out a loud cheer and launch their hats into the sky. At that precise moment, a quartet of Zukits—Israeli derivatives of the Air Fouga Magister jet trainer aircraft—flies overhead.

—Gary L. Rashba

ISRAELI AIR FORCE PUBLIC AFFAIRS

Brand-new Israeli air force pilots fire their hats at Zukit jet trainers.

G-Whiz

A few minutes of combat in a high-performance fighter can leave a pilot feeling as wrung out as a rodeo cowboy who's wrestled a Brahma bull. High-G maneuvers and protective equipment push, pull, and squeeze the pilot, straining the entire body.

A new protective suit that recently gained certification from the German air force could ease the strain by cushioning the pilot's body with liquid, says the suit's manufacturer. And during snap maneuvers, it also could provide quicker protection against the forces of acceleration.

"Modern fighter aircraft can maneuver at up to nine Gs," crushing the pilot with nine times the force of gravity, says Peter Stumpen, vice president of Germany's Autoflug Libelle, which produces the Libelle G-Multiplus suit. Such powerful maneuvers force the pilot's blood into the feet and legs, depriving the brain of oxygen and producing tunnel vision or even G-LOC, G-induced loss of consciousness.

Conventional G-suits encase the pilot's lower body with air bladders, which inflate during high-G maneuvers. Inflation forces the blood in the legs back into the upper body. "Positive pressure" masks provide extra oxygen to the pilot, but require inflatable vests that reduce the chance of lung damage by keeping the lung from overexpanding in thin atmospheres. Pilots tense their muscles and use controlled breathing techniques to further enhance their tolerance of G-forces.

Libelle replaces these components with a single jumpsuit-like garment. Six "fluid muscles" replace the air bladders: two run from shoulder to ankle on the front, two extend over the back, and two run from shoulder to wrist. The fluid (about one gallon per suit) is usually water, although "we're telling pilots they can use anything they like to drink," Stumpen jokes.

Under 1 G, the fluid muscles look like flat ribbons. But as G forces increase, fluid is pulled into the lower parts of the

THAT'S AGRITAINMENT

ROGER MOLA

Carved in Corn

"We figured with the Hazy Center coming to Dulles and all the activity with the centennial of flight, we'd try this theme," says Rick Stevens, manager of the Temple Hall Farm Park near Leesburg Municipal Airport in Virginia. A maze in the shapes of the Wright *Flyer* and the space shuttle—apparent only from an aircraft—spans 10 acres of cornstalks. "At each fork you answer trivia questions about the Wright brothers and the history of flight to find out which way to turn," Stevens says. "If you answer wrong, you can wander around longer." The tribute to the centennial of flight is one of hundreds of works by The Maize, a Utah company specializing in "agritainment." Patterns are plotted on graph paper, then gridded for mowing. "In our first season, a microburst thunderstorm blew the corn acoss the paths and we had to carve them back out with machetes," says Stevens, who last September had to cope with Hurricane Isabel. "It would take a real flattening to put us out of business," he adds. Entrance fees are $7 for adults, $5 for children.

—Roger Mola

tubes, which expand, squeezing the lower body.

"What happens in the suit muscles is similar to what happens in human blood vessels, so there's no time delay," Stumpen says. "The old G-suits, especially when you pull Gs at a high-onset rate, can take up to two seconds to inflate. The pilot has to overcome that just by straining his muscles. The Libelle suit reacts in real time." And unlike conventional G-suits, which plug into the aircraft's air conditioning system, the Libelle suit is fully self-contained.

Germany's Luftwaffe certified the suit for operational use last March, and has already deployed some suits with a MiG-29 squadron. The U.S. Air Force has conducted both centrifuge and flight tests since 2000, Stumpen notes, with extensive flight tests aboard F-15s and F-16s in 2002. There's no word, though, on whether the suit will see regular duty with U.S. pilots.

—Damond Benningfield

Return to Flight: 2005?

After NASA completes the requirements to return the space shuttles to flight, one of the most noticeable changes will be that they won't fly all that much.

Although the missions haven't ended—there's still a space station to finish and a space telescope to service—new restrictions will halve NASA's launch opportunities. Among the new limitations: launching only during daylight so cameras can have a clear view of any falling debris, as well as a good view of the separation of the external tank at 8.5 minutes after liftoff.

NASA

Astronaut Scott Parazynski tries patching shuttle thermal tiles aboard a KC-135 as it simulates microgravity.

Other launch constraints are already in place, related to the shuttle's ability to reach the station's orbit, the occasional meteor shower, shade requirements to keep the shuttle from overheating while docked at the station, and the notoriously fickle weather at the Florida launch site. With the addition of the new requirements, launches are effectively eliminated for periods of up to six months. The fewest launch opportunities fall between October 2004 and March 2005. Given the new restrictions, if the shuttle isn't ready to fly by next October, *Atlantis*, *Endeavour*, and *Discovery* may well stay grounded until early 2005.

At a media workshop in Houston, managers stressed that the focus of NASA's post-*Columbia* safety upgrades is preventing foam loss. Plan B: If an orbiter were to be so damaged that it could not safely return, the astronauts would fly to the space station to await rescue. Preliminary studies show nine people could live in the space station for about 80 days before running out of oxygen or water, says station program manager Bill Gerstenmaier.

Finally, the agency has launched a massive effort to develop a bandage to patch holes in the shuttle's thermal protection system while in orbit. A plan to repair the black silica tiles is fairly well developed, thanks in large measure to a research project resurrected from the early days of the shuttle program, when engineers had no proof the tiles would even stay on during ascent. Astronauts, engineers, and scientists have been working for months with a silicone putty called MA-25S, which, once cured, looks and feels like a pencil eraser. Tests show it can withstand temperatures of 2,300 degrees Fahrenheit, which is what the tiled portions of the shuttle typically experience during reentry. Before the next shuttle flies, NASA wants the capability to repair in orbit a hole in the tile as big as 10 by 30 by 4 inches.

Although NASA has struggled with tile damage on every flight since the shuttle's 1981 debut, an in-orbit repair would have been necessary only once, when a tile actually came off, leaving a gap in the shield. Fortuitously, an antenna shaded the area, keeping it from burning during reentry. "We want to have the availability [for tile repair], but we don't expect to use it," says flight director Paul Hill.

Developing the technology to patch the orbiter's tiles is only one hurdle to overcome before NASA can return to flight. A more difficult challenge is learning how to repair a breach in the leading-edge wing panel, the cause of *Columbia*'s demise. The panel is made of reinforced carbon-carbon, an entirely different substance from that of the tiles. Materials and technologies to fix wing panels, which need to withstand temperatures of about 3,000 degrees, are in their infancy. NASA acknowledges it may never be able to fix a hole as large as the one that doomed *Columbia*.

—Irene Mona Klotz

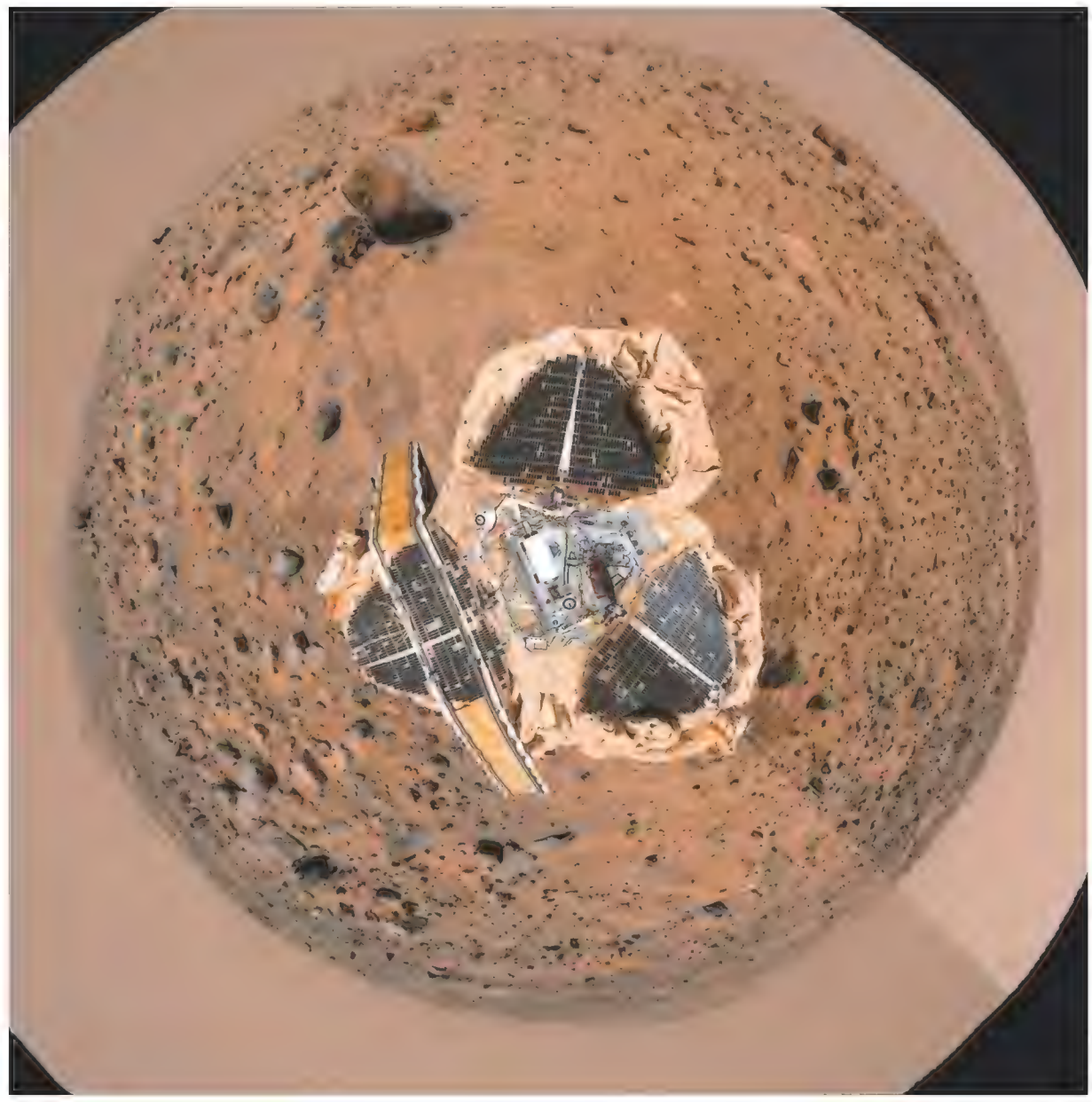
BEST IN SHOW

Screaming Yellow Staggerwing

A 1944 Beechcraft G17-S Staggerwing won the Rolls-Royce Aviation Heritage Trophy at the fifth annual Western Region Invitational, held at Reno, Nevada, last September during the National Air Races. Airshow legend Bob Hoover presented the trophy to owners Larry and Doris Beck of Canby, Oregon. Their Staggerwing was judged the most historically accurate and most authentically restored of the 35 aircraft vying for the trophy. A 1933 Waco UBF-2 owned by Scott Woods of San Francisco was named best antique, a Piper L-4H owned by Colin and June Powers of Monmouth, Oregon, won best warbird, and a 1939 Spartan Executive owned by Kent and Sandy Blackenburg of Groveland, California, was named best classic. Left to right: National Aviation Hall of Fame marketing director Ron Kaplan, National Air and Space Society director Joseph Suarez, Rolls-Royce North American vice president of market development Ken Perich, master of ceremonies Bob Hoover, and Staggerwing owners Doris and Larry Beck.

CAROLINE SHEEN

Not the Real McCoy



JPL/NASA

After arriving on Mars in July 1997, Mars Pathfinder photographed nearby boulders and the six-wheel Sojourner rover. JPL digital artists combined the images to produce a panoramic view of the landing site, and since Pathfinder could not photograph all of itself, the artists superimposed an image of the Museum's engineering model to complete the picture.

Most people would not be surprised to learn that NASA and the Smithsonian Institution have a legal agreement stating that NASA will transfer all artifacts having historical or educational value to the National Air and Space Museum as soon as they become available. The Museum is therefore the official custodian for hundreds of artifacts relating to the science and technology of spaceflight, including launch vehicles, rocket engines, spacesuits, and both manned and unmanned spacecraft. Like most legal documents, however, the agreement has its share of provisos, including one stating that if NASA determines an artifact to have "renewed technical utility," the Museum has to lend it back—even if NASA's second use results in the destruction of the artifact. Because spaceflight technology evolves so quickly, this clause has rarely been invoked: Why use last year's thingamajig when this year's is so much better?

In 1999, however, NASA lost two Mars-bound spacecraft. The failure of both the Mars Polar Lander and the Mars Climate Orbiter forced the agency to reexamine its entire Mars exploration program, and soon one artifact in our collection would find "renewed technical utility"—the engineering model that supported the Mars Pathfinder mission. While the actual Pathfinder lander was operating on Mars in July 1997, the engineering model sat on a mock-up of Mars' surface at NASA's Jet Propulsion Laboratory in California, where it was used to test computer commands and spacecraft maneuvers before they were tried on Mars. The JPL tests on the Pathfinder engineering model, which was outfitted with many pieces of flight-qualified hardware that could have been swapped out with parts on the spacecraft that actually went to Mars, eliminated the guesswork from many important tasks, such as how best to deploy the small parasitic rover, Sojourner.

In spring 2000, curators had just finished the paperwork transferring the Mars Pathfinder engineering model to the Smithsonian, and we were planning to exhibit it in the Exploring the Planets gallery. Then Rob Manning from JPL called. Manning, who had worked on the Mars Pathfinder mission, had recently been assigned as the spacecraft system engineering manager for a new set of missions, the Mars Exploration Rovers. He explained that NASA wanted to deliver two large rovers to Mars using a spacecraft that was almost identical to the Mars Pathfinder lander (see "Next Stop: Gusev Crater," p. 70). His job would be to take all the instruments and systems, put them together, and make sure that they would survive the landing. To do this and meet the summer 2003 launch window, he and his crew had to begin planning and testing as soon as possible, and the only piece of Pathfinder flight hardware that was available was the engineering model that NASA had just handed over to the Smithsonian. Manning wanted to know if JPL could have it back.

As a planetary geologist, I had participated with other scientists in selecting the landing site for Mars Pathfinder, so I had met Manning several times. He is a serious, deliberate man, and I knew he would not ask for the Pathfinder model unless he really needed it. "You know, Rob," I said, "according to the agreement, we have to lend this thing

back to you guys. Uh, you're not going to destroy it, are you?"

"No!" he assured me. "Believe me, the people here at JPL want to see Pathfinder in the Smithsonian as much as you do. I promise, I'll get it back to you in better condition than it is now."

A few days later the Pathfinder engineering model was on its way to JPL, where Manning and his crew subjected it to various tests. Once or twice a year, he would send an e-mail updating us on his team's progress. The Pathfinder model enabled Manning's team to determine how best to deploy the larger Mars Exploration Rovers once the spacecraft carrying them had landed. JPL had also given the MERs newly designed landing antennas, which are used to communicate with scientists back on Earth, and the Pathfinder model allowed engineers to ensure that they would work.

Without the engineering model, JPL would have had to construct entirely new hardware, a step that Manning suggests would have delayed many important tests by at least a year. Furthermore, while the engineering model had originally been constructed in time to provide a year of testing, this time it provided almost three years of continuous testing. All the while, Pathfinder was still officially a Smithsonian artifact.

Three months ago, the Pathfinder engineering model returned to the Museum. Curators anxiously opened the shipping crate. Had three years of testing done any damage? Fortunately, the spacecraft looked like new. Rob Manning had kept his promise.

—Bob Craddock is currently serving as science advisor to Smithsonian Institution Under Secretary David Evans.

Final Countdown

After more than two years of construction, the National Air and Space Museum's Steven F. Udvar-Hazy Center opens on December 15. The aircraft hangar, control tower, theater, and other structures required 40,000 cubic yards of concrete, 6,500 tons of steel, 12 miles of ducts, and 800,000 square feet of roofing. One of the artifacts on display is a North American Rockwell Shrike Commander 500S (right), which was donated to the Museum in 2000 by former test pilot and airshow performer R.A. (Bob) Hoover. The Shrike Commander was designed as a business aircraft, but Hoover, who bought one in 1979, flew it in airshows, building his routines around a series of rolls, loops, and dead-stick landings.

JIM KOEPNICK, EAA

CAROLYN RUSSO

A U.S. Air Force SR-71 awaits placement in the Steven F. Udvar-Hazy Center.

MUSEUM CALENDAR

December 9 A Salute to Military Aviation Veterans. The National Air and Space Museum will honor military aviation veterans by inviting them to be among the first to celebrate the opening of the Steven F. Udvar-Hazy Center. This open house is for aviation veterans and their guests. Due to space and safety requirements, attendance is limited to 4,000 people on a first-come/first-served basis. Tickets are $15 and are limited to four per veteran. To purchase tickets, visit *www.one-stop-registration.com/smav/* or call 1-866-814-4441. Steven F. Udvar-Hazy Center, 10:30 a.m. to 3 p.m.

December 15 The Steven F. Udvar-Hazy Center opens to the public. Will you be the first one through the door? Come by for a fun-filled day, with staff members on hand to answer your questions about previously unseen artifacts. Enjoy the music of local high school bands and leave with some give-aways. 10 a.m. to 5:30 p.m.

December 17 Centennial of Flight Celebration on the National Mall. Visit *www.nasm.si.edu* for information about the day's events.

December 20 Family Day at the Steven F. Udvar-Hazy Center. Bring the whole family to take part in hands-on activities and listen to guest speakers. See such sensational artifacts as an Air France Concorde and the space shuttle *Enterprise.* 10 a.m. to 3 p.m.

Lockheed Martin IMAX Theater View Earth from the open cargo bay of the space shuttle. Journey to natural and manmade wonders of the world. These and other thrills await you at the Lockheed Martin IMAX Theater, where large-format films are projected onto a screen five stories high and audio is broadcast through a six-channel digital surround sound system. For information on schedules and showtimes, call (202) 357-1686 or (202) 357-2700.

Except where noted, no tickets or reservations are required. To find out more, visit www.nasm.si.edu *or call Smithsonian Information at (202) 357-2700; TTY (202) 357-1729.*

The Invasion of Manchester

Airline passengers traversing New Hampshire's Manchester Airport glimpse a serene, wooded landscape under the wing. On the ground, they navigate a bustling terminal surrounded by vigorous commercial growth. But in my mind's eye, I see the airfield in another era and another season.

I came to Manchester on November 2, 1942, less than a year after the Japanese attacked Pearl Harbor. I was a newly minted fighter pilot, 20 years old and three months out of flying school. The airport was then a brand-new U.S. Army Air Forces base called Grenier Field, after a local Army Air Corps pilot, Lieutenant Jean Grenier, who had been killed in 1934 while on a training mission.

My outfit, the 315th Fighter Squadron, had formed only six months earlier. I was one of 28 pilots who, with about 260 ground personnel, had come to New Hampshire in the dead of winter to train for what we assumed, given the climate, would be a campaign on the polar icecap. Military secrecy being what it is, any German spies lurking around New England probably knew we were actually preparing for an invasion of North Africa.

Our aircraft was the Curtiss P-40F. Some of us had never flown one before. In those days, before flight simulators and two-seat training versions, we learned to fly a single-seat fighter by getting in it and taking off. We pored over the pilot's manual, spent an hour in the cockpit memorizing the instrument panel, and got some advice from a "veteran" pilot who had logged a few hours in it. Then we donned bulky fleece-lined gear, stuffed ourselves in the narrow cockpits, and prepared to taxi for takeoff.

After checking every switch and instrument three times and straining my ears for every snap, crackle, or cough in the big 12-cylinder, 1,300-horsepower Merlin engine, I ran out of excuses and, pointing the long nose toward the pine woods at the end of the runway, pushed the throttle forward.

From aloft on a clear day, New Hampshire was a vast rumpled white blanket embroidered with brown. Much of the time, we saw the landscape upside down as we twisted and looped, learning what the P-40 could do. We managed to stall the airplane in almost every conceivable attitude and somehow recover before running out of altitude.

Back on the ground, life was vastly more complicated. The 315th and Manchester were a poor match from the start. The trouble began at Grenier Field, where the base commander, a colonel (and probably a bomber pilot), developed an instant dislike for us. He refused to allow our ground crews use of the lone hangar during the day, so mechanics had to work outdoors in the cold. To keep the engines warm, they started them up periodically throughout the bitter nights.

The colonel also posted rules for pilots, including a ban on flying under the Merrimack River bridges. One of our pilots promptly flew under the Notre Dame bridge during the early morning rush hour, causing two startled drivers to crash into each other, although without any serious injury. The pilot was summoned before the base commander. His defense was that the idea of flying under the bridge would never have entered his mind if it hadn't been specifically prohibited. He lost his case and was confined to base for two weeks.

It was a laughable sentence. Although the field was surrounded by a high fence and the official exit was through the main gate, a large culvert at a remote location on the perimeter enabled free-flowing traffic.

The townspeople of Manchester, although rightfully concerned about the

The author (above) admits that he and his squadron mates did their best to mimic "the insouciance of Britain's Royal Air Force pilots." The squadron insignia, originally Bugs Bunny (right), was replaced by the more dignified Crusaders (top left).

COURTESY MARSHALL LUMSDEN (3)

threat to the morals of the local young women, viewed us with what sometimes seemed like excessive suspicion. One of our men booked a room in the downtown hotel when his wife came to visit. The hotel detective stormed in demanding to see their marriage license. Fortunately, she had it with her.

It was also true that we weren't easy to like. We found the city to be rather dull. After all, we were a fighter outfit headed off to war, and we were full of beans. We adopted what we assumed to be the raunchy insouciance of Britain's Royal Air Force pilots. When three or more of us got together in public, we were prone to break into ribald song. Deplorable rowdiness became a hallmark at the USO club in Manchester.

Our squadron commander, a 25-year-old captain, in addition to being a fine leader and a skilled pilot, could mesmerize a crowded barroom with his imitations of cartoon characters. This talent inspired the design of our first squadron insignia: Bugs Bunny reclining on a cloud, a .50-caliber machine gun resting on a foreleg. Until well into our second overseas campaign, we were known as the Bugs Bunny squadron. A new commander sensibly changed the name to the more threatening Crusaders.

We trained by flying all over New England. We hopped over to Portsmouth to practice gunnery offshore, where, if we were lucky, we'd spot a Navy Hellcat or a Corsair, which would automatically trigger a dogfight. There were fewer regulations in those days, and we flew too low as well as too high. Frozen lakes were inviting targets for buzzing, with the goal of getting the fishermen to dive for the ice.

Sometimes fast-moving snow showers would scoot in under us and we had to dive beneath the clouds, hunting in almost zero visibility for the railroad tracks, which ran north and south, to follow back to Grenier. One sunny day, a P-40 lost power, bellied in on a snowy field, and plowed into a stack of railroad ties with such force that the engine was torn away. It was testimony to the airplane's construction that the pilot hurt only his hand.

Amid our shenanigans were events we'd recall less fondly, if no less vividly. One morning as I sat with engine idling, waiting for takeoff, I watched a P-40 ahead of me stall, crash into trees, and burn at the end of the runway. The pilot was a new one, and I scarcely knew his name and cannot remember it now. He lasted two days in the Manchester hospital before dying from burns.

Finally, on February 15, under sealed orders, we boarded a bus for the train station in Boston. The base commander also got on—to make certain, he said, there were no stragglers. From Boston, we entrained for the balmy air of West Palm Beach, Florida, drinking booze and singing chorus after chorus of "O'Reilly's Daughter." The ground echelon, meanwhile, went by train to San Francisco, where they caught a troop ship for a 40-day cruise across the Pacific to the Middle East. In Florida, we found that we were headed for Africa, and boarded military air transports for the Gold Coast and Nigeria.

In Lagos, we picked up newly assembled P-40s and ferried them across sub-Saharan Africa to Khartoum, down the Nile River to Cairo, and then to a base near the Suez Canal, where we finally met our ground crews. Together we moved up to the front in Tunisia. In May 1943 I survived my first combat mission and my 21st birthday.

Less than six months after departing Grenier Field, we had lost nearly a third of our pilots. At the end of the war, the outfit was demobilized in Stuttgart, Germany. The ground crews had endured a two-and-a-half-year camp-out, working outdoors in all kinds of climates, including a hot North African summer and two cold, wet, muddy European winters. Eager replacement pilots had taken over for most of the original veterans, and the P-40 was replaced by the faster, more powerful P-47 Thunderbolt. The squadron, as part of its parent outfit, the 324th Fighter Group, had flown a record total of ground support missions, destroying prodigious numbers of enemy installations, railroads, and rolling stock. The group was awarded two Presidential Citations and a Croix de Guerre, and at least one French town officially memorialized the 324th for its role in helping to liberate their country.

Many of those who survived the war went home to raise children and lecture them on irresponsibility and recklessness. The pilot who flew under the bridge completed 198 combat missions in Europe, received two Distinguished Flying Crosses, and retired as a colonel after a long military career. The pilot whose airplane came to grief in a pile of railroad ties became an Episcopal priest and a noted human rights and anti-war activist. The 315th ordnance officer married a pretty Irish girl from Manchester. They lived happily ever after near Boston, although in later years mainly in Florida. They never go back to Manchester in the winter, he tells me. Nor, to my knowledge, have any of the rest of us. New Hampshire ice fishermen must have found some peace after we left. At least they no longer were the target of hare-brained kids in P-40s swooping down at full speed.

—Marshall Lumsden

Chasing the JB-2

The pilotless V-1 "buzz bomb" was one of the advanced German weapons that U.S. forces were able to retrieve before Russian army units got to them. The winged cruise missile earned its name from its unique pulse-jet engine, which produced a raucous buzzing. It could not aim for a specific target—after a timer terminated its flight, it simply fell to Earth in a general target area. The sound of an approaching V-1's engine was terrifying, but even more so was the silence that followed when the engine quit: It meant the bomb would fall—nearby—in 10 seconds.

After the war, some of the captured V-1s were studied and tested. Republic Aviation built some 1,300 copies, which were called JB-2s. In 1948, at Holloman Air Force Base in Alamogordo, New Mexico, the White Sands Proving Grounds unit attached rockets to them and launched them off a slightly inclined railroad track.

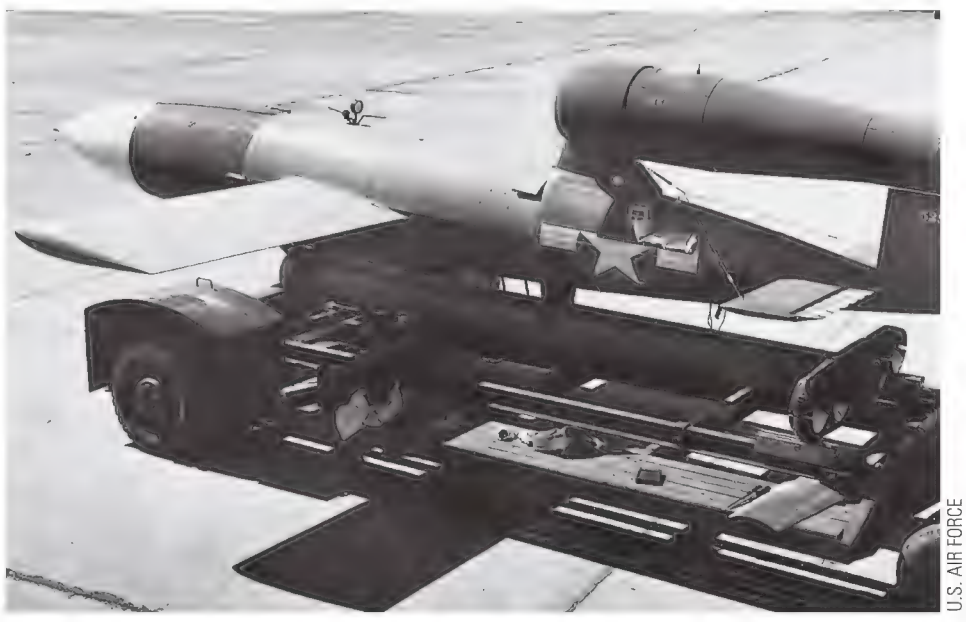
Our Fighter-Gunnery Research Squadron at Williams Field, Arizona, provided two chase planes. A P-51 would fly off the JB-2's left wing just as it left the launch rails, and a P-80 would fly high cover on the right at about 5,000 feet.

At times, the JB-2's faulty gyro stabilization would make the flight erratic, so the chase planes were armed in order to bring down a runaway—but of those I chased, only about half were good launches. Some launches were aborted on the pad. Others crashed right after leaving the rails. (I've always wondered how many the Germans must have pranged for every one that succeeded.) On a good flight, the JB-2 would be boosted to about 240 mph on rocket burnout; then it would accelerate to about 400 mph for a level flight to the predicted impact area.

One fine day in June, I was flying the high-side P-80 with four of six .50-caliber machine guns loaded when a JB-2 was fired off at its designed speed of 240 mph—a perfect launch. It quickly outran the P-51 and, keeping low, accelerated to 400 mph. I stayed high and was able to keep up with it. After about 30 seconds, it began dipping the right wing, turning a few degrees each time. It was about to leave the range area and head directly for the town of Tularosa.

Unsure when the JB-2 would exhaust its fuel, I radioed Range Control that I was going to bring it down. The response was "Roger, Roger. Nail it."

I wheeled in and opened fire at about 1,200 feet. The first rounds blew it into a fireball that I could not avoid—I flew right through it. My engine quit at a less-than-desirable altitude of 300 feet. With an airspeed above 500 mph, I was able to zoom up to a more accommodating altitude where I could attempt an engine air start—which was unlikely to be successful. And early P-80s had no ejection seats. If you wanted out, you had to jump.



U.S. AIR FORCE

The JB-2 was a knockoff of the German V-1 "buzz bomb" cruise missile.

No matter how smooth the desert looks from the air, it's a bad idea to land on it. Deserts aren't smooth. And at Alamogordo, there was lava rock here and there. Moreover, I didn't want to jump out of that beautiful shiny P-80. Our outfit had only six of them, and I was flying the best one. I tried air starts over and over, with no luck. I was gliding through about 2,000 feet when off to the left I saw a big patch of sand with no vegetation, no lava—just white sand. I could save the airplane!

But I messed up. I misjudged how far the P-80 would glide without the landing gear sticking out in the slipstream and creating drag. I saw my nice smooth area go by, and by, and by…. I was committed to your standard desert with all its bumps and bushes and lava.

After a lot of noise and bumping around, it got real quiet. My P-80 was banged up, but Lockheed built them tough. As for me, I suffered only ego damage.

I got out and disconnected the battery to avoid sparking a fire. After checking everything, I sat down and pulled out a cigarette. Then I remembered I'd used my last match lighting a smoke during the range briefing just before takeoff. Then: inspiration. Since no fuel seemed to be leaking anywhere, I hooked up the battery again and gathered a bunch of sagebrush and sticks about 100 feet in front of the airplane. Back in the cockpit, I put my helmet on, turned on the gun switch, closed my eyes, and pulled the trigger on the control stick. Not one of those four guns hit the pile.

I was out there for three hours. When the ambulance finally bounced in, a corpsman jumped out and asked, "Are you okay?" "No," I said. "You got a match?"

Damn that JB-2, and you know what? I forgot to fill out the flight form, so I didn't even earn credit for the 20 minutes of flight time.

—Brigadier General David W. Winn U.S. Air Force (ret.)

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God Save

Why an aged nuclear bomber makes a Briton's heart sing.

by Craig Mellow

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A Vulcan pull raised money for charity in 1995, but if a Vulcan is ever to fly again, the effort will take not just muscle but money from a national lottery.

Three years ago, Robert Pleming was a walking advertisement for Tony Blair's prosperous, post-industrial Britain. He had an enviable job as U.K. technical director for the Internet networking company Cisco Systems, an MG convertible for middle-aged weekend adrenaline—an ordered, comfortable life. Today, the Cisco job is history, along with several hundred thousand pounds in savings, and the MG is pushing 90,000 miles. Pleming's new life centers on a 30,000-square-foot hangar at Bruntingthorpe airfield in the English Midlands, where a stripped-bare, 43-year-old Vulcan nuclear bomber broods in fluorescent purgatory, surrounded by hundreds of boxes containing its engines and innards.

But Pleming doesn't regret his change of circumstances. Not so long, at least, as hope lingers that the boxes will be unpacked, each precious component quality-tested and reinstalled, and the great airplane, all 111 feet of it from wing tip to delta wing tip, will roar back into the sky for the first time in a decade. Coming to the end of our tour of its fuselage, Pleming draws up short when he notices a crate of original Vulcan technical drawings, on loan from the Royal Air Force Museum in London, detailing cockpit circuitry or left-side engine airflows. They're big square 1950s things on plaster board with wooden frames, and he flips through them reverently, murmuring, "I could look at these all day."

The 48-year-old Pleming, whose (unpaid) job title these days is director of Vulcan To The Sky Ltd, isn't the only outwardly normal Briton to fall under an obsolete weapon system's spell. Just as 100 or more Vulcans were at times dispersed throughout the United Kingdom, ready to scramble at four minutes' notice and strike at the heart of the Soviet Union, Vulcan freaks are scattered across the same territory. In the northern English city of Middlesbrough, postman Craig Bulman snaps up every photograph he can find of the cold war machine and swears he can see distinguishing marks on almost every aircraft, much as a shepherd can with his sheep. "Now this is one that was retrofitted to carry American missiles," he barks excitedly, jabbing his finger into what the untrained eye takes to be a row of absolutely identical Vulcans on a long-ago runway. "The more you study these things, the more you learn that's new about them!"

At Southend, where the Thames flows into the sea east of London, water company executive Kevin Packard, who is also chairman of the Vulcan Restoration Trust, tries to explain why a dozen men from his group spend weekends getting greasy under their Vulcan, keeping it in shape merely to taxi twice a year. "When you look at the thing, you know you've just got to keep it going," he says. "You can't let it fall to pieces."

In Belfast, retired Royal Air Force pilot Andy Leitch maintains the authoritative Web site, *www.avrovulcan.org.uk*, where forum members with handles like "Wyrdrune" and "Alamo" swap lore comic and tragic—from recalling how they primed the combustion chamber to produce a six-foot flame as a hazing ritual for new ground staff to debating the caus-

ABOVE: BAE SYSTEMS/NASM (SI NEG. #1A-04984)

es of a fatal 1963 crash. "I went on to bigger things in RAF terms after being a Vulcan copilot from 1974 to '79," Leitch says. "But most of my warm feelings about the service go back to Vulcan just the same."

Part of the Vulcan's allure, its rare technological marriage of ferocity and grace, comes to life in the old film clips Pleming calls up on his laptop. You see the 130-ton beast ignite its four 17,000-pound-thrust engines. Its structure is virtually all wing save for the 30-foot potbelly bay designed to hold a single Blue Danube nuclear gravity bomb roughly the size of a London bus. The bomber accelerates to 100 mph on the runway with a din Pleming likens to that of an angry bear, though when I heard it at one of last summer's taxi runs, it sounded more like a buzz saw rending the sky in two.

Then it—or "she" as the aficionados prefer—lifts off as lightly as a seagull, climbing at 60 degrees, rolling playfully, then banking until its great bulk is perpendicular to the earth, turning easily to stay within view of an airshow crowd. If the pilot wanted it to, it could also fly steady as a plate at any altitude between 62,000 feet and 300 feet. "People who are in their 30s now still remember seeing the Vulcan at shows," Andy Leitch says. "It's a bomber that flies much more like a fighter. And it made one heck of a noise."

The prototype's wing had a constant angle of sweep; tests led to a trademark leading edge kink in wings of production craft.

But Vulcan fanaticism has another root as well, one you can't see but have to listen for. The airplane is a vanishing symbol of vanishing strategic industrial might, and it still fires up feelings in a swath of Britain that the Yankee tourists don't ordinarily see, equally distant emotionally from top hats and punk rock. This is a Britain of gear boxes and patriotism, eager to recall if not relive the spirit that commissioned three nuclear strike aircraft designs

VULCAN TO THE SKY

Above: Robert Pleming and his cause. The Vulcan fuselage housed five crew members, but only the pilots had ejection seats. Left: A drag chute eased wear on the big bomber's tires.

even as essential foodstuffs were still subject to post-World War II rationing, then built them as well as the Americans built bombers, if not better. A Britain that turns out six million people a year at airshows, numbers that run second only to the national proto-religion of soccer.

"The Vulcan is one of the most iconic British aircraft," says Richard Clarkson, a sports marketer from the London suburbs who in his spare time heads the Vulcan Restoration Trust with Packard. "It's an aircraft that talks to its public."

Its last chance to speak from the sky, however, is now: A decision is due this month on Pleming's request to the British Heritage Lottery Fund for a £2.9 million ($4.6 million) grant to buy the Bruntingthorpe Vulcan and restore it to flying condition.

The RAF retired the Vulcan from service in 1984—ironically, just after it finally dropped its first bombs in combat, crippling an Argentine airfield in the Falklands War. The icon hung on at airshows for another nine years, and 16 remain intact today as museum pieces. But only the one under Pleming's care, known to insiders by its serial number, XH558, could theoretically fly again.

That is, if the lottery fund changes its mind after turning down the Vulcan last year. If not, the end has come. Cecil Walton, the Bruntingthorpe owner who bought XH558 for love in 1993—along with all existing Vulcan spare parts—has died. His son David takes a more practical view of contributing 30,000 feet of hangar space. If the cash doesn't come through this time, the airplane will be scrapped, Pleming says. Or, worse still in the eyes of some enthusiasts, be sold to an American.

"What got me involved in this was hearing a few years ago that the XH558 might end up in the U.S.," says Felicity Irwin, who runs a London public relations agency and volunteers as Pleming's spin doctor. "I said, 'Over my dead body!' "

Pleming's account of his own motivation is no less dramatic. "This is my own personal Everest," he says, squaring his shoulders for a final assault on the peak. "I'm either Mallory or Hunt, I'm just not sure which yet."

Pleming should know soon. John Hunt reached the summit of Everest in 1953, survived to write a book about it, was made a baron, and passed away peacefully at age 88. During his summit attempt of 1924, George Mallory died on the mountain.

It was an Englishman, John Milton, who wrote, "They also serve who only stand and wait." The words might have been dedicated to the Vulcan three centuries later. From 1956 to 1969, it toted Britain's (and an important part of NATO's) frontline deterrent to the Communist nuclear threat. The bomber was designed to fly above the reach of radar and missile, but after the Russians brought down Gary Powers' U-2 spyplane in 1960, the Vulcan switched, with some effort, to flying below detection. The airplane's ultimate service was

that its payload was never used.

It was actually the United States that set the Vulcan project in motion. In 1948, a cold-war-stoked Congress passed the McMahon Act, excluding foreign nationals, Brits included, from U.S. nuclear programs. The U.K. didn't blink, even under Clement Atlee, Winston Churchill's far-left successor as prime minister. The government ordered not one nuclear bomber of its own but three, from three British aircraft manufacturers, all of them gone now.

Handley Page of Reading offered the Victor. Vickers of Newcastle built the Valiant. (Vickers still exists as an armored-vehicle maker.) The Vulcan—its name borrowed from the Roman god of fire—was created by A.V. Roe, outside Manchester, under the direction of master designer Ray Chadwick. The company had built the Lancaster, the RAF's workhorse World War II bomber, and its contribution to the "V-Force," as the three bombers became known, was again the best of its breed.

It also reflected the aerodynamic fashion of the time. Allied intelligence had captured German World War II research on all-wing aircraft and delta-wing designs, and aeronautical engineers were beguiled by the purity of the flying wing. In the United States, Jack Northrop produced an experimental flying wing in 1946, but two Northrop prototypes crashed. Later critics of that design judged that putting everything in the wing—the cockpit and fuel tanks—had made it so thick that at high speeds airflow around the wing separated, became turbulent, and caused the aircraft to buffet and lose stability.

Vulcan designers found similar problems with the first model they sent to Royal Aircraft Establishment wind tunnels. They had started with a more radical, all-wing design; the test results persuaded them to reduce the wing's thickness by withdrawing the crew compartment, placing it instead in a short forward fuselage. Later, they added a conventional centrally mounted fin and rudder.

And still they faced difficulties. A prototype test flight ended in a fatal crash in 1949. A.V. Roe called on its chief test pilot, Roly Falk, to continue the test program. One of two or three fliers who could claim to be the British Chuck Yeager, Falk was known as "the pinstriped pilot," because he preferred to fly in a three-piece suit and "if the cockpit wasn't absolutely clean, he wouldn't go up," his son John recalls.

Falk had flown 350 different types of aircraft by the time he took the Vulcan's controls, even surviving a 1947 accident in which

Below: Kevin Packard (left) and Richard Clarkson helped transform XL426 from a corroding static display (right) to a runway racer.

OPPOSITE:©MARK WAGNER / AVIATION-IMAGES.COM; ABOVE:© 2000 PHIL WHALLEY

RIGHT:©MARK WAGNER / AVIATION-IMAGES.COM; ABOVE:© 2000 PHIL WHALLEY

he crashed through a house and ended up with a metal stanchion lodged in his throat. He nursed Chadwick's monstrous creation through five more years of test and modification, ending in the summer of 1955 when, starting at a height of 300 feet and watched by a gaping crowd at the Farnborough Air Show, he rolled the big bomber. By the following year, Vulcans were in production and poised on the front line of freedom, each one packed with more destructive power than was dropped in all of World War II.

The Vulcan represented a great leap forward from the Lancaster and the larger, farther-reaching Lancaster descendant, the Lincoln, whose four piston engines pushed it along at a top speed of 290 mph. The new airplane reached 630 mph when it cruised at unheard-of 60,000-foot altitudes. The Vulcan was more complement than competitor to its great U.S. contemporary, the B-52—as a swift, get-on-base shortstop complements his muscle-bound clean-up hitter. "The B-52 was an extension of the Superfortress concept the Americans pioneered during the war," observes Pleming, who earned a doctorate in nuclear physics in his youth before entering the computer industry. "[The B-52] was loaded with defensive systems and designed to deliver a knockout punch. The Vulcan flew faster than most fighters at the time, and because the engines were inside the wings, it had a stealthy design with a very low radar cross-section."

The Vulcan in fact flew without fighter escort, and with no guns of its own, on the assumptions that Soviet defenders couldn't catch it and antiaircraft fire couldn't reach it 12 miles up. The second assumption crumbled in 1960, when the Russians downed Powers' CIA spyplane at 67,000 feet. But that, Vulcan groupies insist, is when Chadwick's genius became fully apparent. For the great bomber, with enormous wing area and buried engines, could hug the ground as well as cruise the stratosphere.

It could do it all right, but a price was paid, according to retired RAF Air Vice Marshal Ron Dick, a former Vulcan squadron commander and a contributing editor to *Air & Space/Smithsonian*. "An aircraft designed for high altitude does not lend itself terribly well for low-level operations," says Dick. "It was designed to withstand 2 Gs. You've got to be amazingly careful in the thicker air at lower altitudes to keep the indicated airspeed below about 350 knots because it couldn't bear much stress.

"It was a wonderful airshow airplane, and I flew it at a number of airshows. But it is questionable whether it could have been effective flying at low level in a war against a nation as powerful as the Soviet Union."

The Vulcan did inarguably play the strategic nuclear first-strike role until 1969, when Britain's generals transferred that service to the Polaris submarine. The bomber then began a 15-year twilight. First it was rearmed with tactical nukes. Later it was relegated to reconnaissance, and even, on occasion, refueling, its prodigious bomb bay converted to a gas station.

The Vulcan served aviation as a test bed for the engines that would power the Concorde supersonic airliner. And it got a last turn in the limelight in 1982 with the five "Black Buck" raids on the Falklands. These were 8,000-mile round-trip sorties with each Vulcan supported by 11 refueling craft, the longest bombing runs in history until U.S. attacks on Afghanistan two decades later. The Vulcans, each one packed with 21 1,000-pound bombs, effectively

VULCAN TO THE SKY

XH558 (left) was the first Vulcan B. Mk. 2 to enter service and, in 1993, the last to retire. Along with Handley Page's Victor (opposite, top) and Vickers' Valiant (bottom), the Vulcan was on nuclear standby from 1956. Crews could scramble (below) in four minutes.

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OPPOSITE: NASM (SI NEG. #00004967)

BELOW: NASM (SI NEG. #93-4023); LEFT: ROLLS ROYCE / NASM (SI NEG. #1A-05001)

Rolls-Royce borrowed Vulcans for engine research (above), including testing of the Concorde's Olympus 593. Left: In 1961 Vulcan and B-52 pilots were training for the same mission. Vulcans were painted white to reflect the heat of a nuclear flash.

cratered the Argentines' runway.

Two years later, the RAF retired the Vulcan from active duty. Britain never built another strategic bomber; Polaris plays its nuclear deterrent role to this day. The Vulcan was the last of the breed.

So who cares? Britons can relive their finest hour half a dozen times a summer as RAF-preserved Spitfires, Hurricanes, and a single Lancaster soar through World War II reenactments at airshows across the land. Fifteen Vulcans, aside from Pleming's XH558, are on view around the U.K. Two of them still taxi: Packard and Clarkson's baby at Southend and a rival at Wellesbourne airfield, near Stratford-upon-Avon. A crowd of some 3,000 braved a sweltering Father's Day afternoon to see the Wellesbourne specimen spool up and do three minutes on the runway, murmuring in awestruck tones: "It's sooooo big" and "Turns on a dime!"

Three weeks later the Southend Vulcanites threw an Open Cockpit Day. There, more red-blooded English families steered their wide-eyed youngsters through the claustrophobic, dials-mad space where five crew members spent 16 hours during the Black Buck raids, the two pilots crammed in the tight cockpit. The audience was rapt by the lore volunteers shared about soup heaters the pilots used and the "P-tubes" they urinated through.

The Vulcan, in short, is still stoking plenty of national pride on the ground. Should Britain really spend £3 million of public funds so it can fly again for five or six years, after which the 600 tons of spare parts stockpiled at Bruntingthorpe will be exhausted? Even that lifespan depends on Pleming's so-far empty assurances that private sponsors will pick up XH558's running costs once the lottery pays for the craft's return to airworthiness. "The underside of those wings would make a perfect advertising space for Richard Branson or somebody," hopefully postulates Dave Griffiths, a financial software programmer who edits the Vulcan Restoration Trust's *Vulcan News*.

"We're very supportive of Dr. Plem-

ing and have been tremendously inspired by what he and his team have achieved," says a diplomatic Henry Hall, chief curator at the RAF Museum at Hendon. "But it is a finite project, and aviation already gets a disproportionate slice of Heritage Lottery funds."

The lottery board, which makes grants to preserve parks and gardens, historic buildings, museum and library collections, and other items of transportation besides airplanes, apparently thought along similar lines when it rejected Vulcan To The Sky's grant application last year. Yet more people cared about the cold war titan than the committee probably reckoned on. Scorned Vulcan devotees resorted en masse to a beloved British tradition, the irate letter to officialdom. Pleming says he was copied on 400 e-mails directed at the Heritage Lottery, some of them quite vociferous. "Lottery funding is given to lesbians, gays, illegal immigrants, and the arts as if there is no tomorrow," objected Derek Evans, a retired Vulcan squadron leader. "If it wasn't for aircraft like the Vulcan, we may not be enjoying the freedom we are enjoying today."

Colin Marshall, occupation unspecified, made a quieter argument from the world of science, sort of: "Even if you felt that it was against your personnel [sic] beliefs, that maybe you are a pacifist and it would not be PC to support the project, you cannot ignore the engineering skills, innovation and so much more that the aircraft has brought to this country, its people, and the rest of the world."

And the *Daily Mail*, one of Britain's great pot-boiling tabloids, added an editorial comment, phrased more tersely: "What a Shameful Way to Treat Our Heritage!"

The Heritage Lottery commission, which after all dispenses between £300 and £350 million a year, noticed. While making no promises for 2003, the judges "have worked closely with us" plugging holes in Vulcan To The Sky's second grant application, Pleming says. The group trimmed the proposed schedule to five or six flights a season, extending the airplane's airborne life to more than 10 years. The advocates also designed an exhibition to tour with the Vulcan, deferring to the lotterycrats' desire for "more interpretation and explanation."

All told, Pleming's revised request runs to 800 pages. If it's approved, he calculates (perhaps a tad optimistically) that 30 million more people will witness the Vulcan in flight before it is sent to its final, well-deserved resting place at the Imperial War Museum in Duxford. If not, Pleming is caught in a Catch-22. He had to dismember XH558 so that parts manufacturers (more than 100 of them laboriously tracked down) could certify their bits as still functional. Without the lottery money, most of which would fund still more laborious Civil Aviation Authority approvals, he can't afford to put it back together.

To hear the faithful recall their own Vulcan experiences—most of the memories generously doused with the presumed lost grace of old-fashioned British childhood—you might think Pleming's toil and treasure, not to mention a paltry £2.9 million in public funding, was all worth it. To Craig Bulman, the north-country postman and manic cataloguer, the Vulcan was his companion on walks home from school across the sodden Middlesbrough fields, roaring through an overcast sky out of the bomber's nearby home base, RAF Waddington. Ian Glasse, who heads Vulcan To The Sky's member fundraising (they've got £1 million in the kitty to match the lottery funds), remembers the mighty airplane droning over the beaches of Dorset, in England's bucolic southwest, where he spent his summers as a youngster.

Felicity Irwin encountered her first Vulcan at 12 years old in her native New Zealand, when it blazed in to mark the opening of an airport, then blazed away as the pilot discovered the runway was too short. "When we saw this fantastic giant wave its wings goodbye, then turn and disappear again over the horizon, everyone was ready to cry," she remembers.

Conceived in the year of the Berlin airlift, constructed during Joe McCarthy's heyday, and primed to counterattack the U.S.S.R. during the Cuban missile crisis, the Vulcan bomber was an integral part of the most terrible calculations human warriors have ever made. It was a frontline offensive weapon whose mission was to rain destruction and death on a virtually unimaginable scale. That it ended its active life half a century later as a sentimental favorite is the ironic fate of many weapons. It is a happy irony to contemplate, however, whatever happens on Dr. Pleming's private Everest.

Twenty Vulcans remain (three in museums at U.S. Air Force bases: Offutt in Nebraska, Castle in California, and Barksdale in Louisiana). Like XL426 at Southend (right), most wear camouflage, applied when the bomber's mission changed to low-level penetration.

"IT'S ALL ABOUT FIRE SMOKE AND NOISE"

IF HARLEY-DAVIDSON BUILT ROCKETS, THIS IS WHAT THEY'D LOOK LIKE.

[illegible]

BY PRESTON LERNER

At first glance, it's a scene straight out of a Norman Rockwell painting: father and son bonding as they kneel to insert an igniter into the base of a model rocket. But the kid isn't nine-year-old Nick Braye; it's his dad, Randy. And their toy rocket isn't one of those lightweight jobs you can set off in your back yard. It's a fearsome eight-foot-tall projectile powered by a solid-propellant motor similar to those in the space shuttle's 126-foot strap-on boosters, and it appears to be fully capable of taking on cargo–or taking out an F-16, for that matter. Ideally suited, in other words, to the mega-launchfest known as Large and Dangerous Rocket Ships.

Despite the ominous name, LDRS isn't a workshop for budding Dr. Strangeloves. It's the world's largest annual celebration of high-power rocketry—serious projectiles, launched by serious adults, that fly exponentially higher, faster, and farther than the balsa-and-Elmer's-glue creations of yore. The first LDRS, an outlaw event held 22 years ago, drew 47 entrants, onlookers, and groupies. This year's gathering, in Argonia, Kansas, featured thousands of spectators and more than 500 rocketeers, flying everything from scale-model V-2s to a technological marvel that has a Federal Aviation Administration waiver to exceed 30,000 feet.

With more than 150 pounds of thrust, Braye's Bobcat—so named because it wears the colors of his Marshalltown,

PHOTOGRAPHS BY RIC WOLFORD

Iowa high school—represents the heart of high-power rocketry. So too does the middle-aged Braye. "I was a child of the Space Age," he says. "I flew my first rocket in 1968, built three Saturn Vs, had a *National Geographic* map of the moon on my wall so I could plot where every mission landed. But then I found out about girls and cars, and I forgot about rockets in 1971. I didn't get back into them until 1997. I wanted to buy my son a birthday present, and when I started snooping around the Internet, I couldn't believe how much rockets had changed. I thought to myself, *Wow, they've got some really big stuff now.*"

Braye is what's known as a BAR—a born-again rocketeer. Hundreds of others with eerily similar stories have braved 100-plus-degree heat to congregate in a field an hour southwest of Wichita in what is, if not technically the middle of nowhere, then not far from it. The organizers of LDRS XXII have set up 50 launch pads, each wired to a central launch control panel. The smallest rockets are lit off a few yards from the viewing area. The biggest boomers, meanwhile, must be trucked to a pad a half-mile away.

Braye and his son secure the Bobcat to a vertical launch rod welded to a metal plate that will shield the ground from the blast of the rocket. The rod is designed to guide the Bobcat into a vertical launch; otherwise it will slew sideways and become what rocketeers call a land shark—a rocket that comes off the launch rod and slides along the ground under power. Braye puts his ear to the Bobcat's casing to make sure the altimeter is beeping properly. "Please work like you're supposed to," he murmurs before he and Nick clear the pad as the launch control officer prepares to trigger the ignition. The P.A. system announces: "Randy's flying a scratch-built rocket on an AeroTech K695R motor. Randy's rocket is going in 5-4-3-2-1."

The rocket ignites with a sibilant roar. Liftoff has none of the gravitas of a Saturn V launch. One second, Braye's rocket is on the pad; next, it's 200 feet high, 500 feet, 1,000 feet, zooming on a bright red flame. After two and a half seconds, the motor cuts out, but the rocket silently keeps on climbing–4,000 feet, 5,000, 6,000. Braye and his son crane their heads and steeple hands against foreheads to follow the Bobcat's progress. "C'mon, baby," Braye urges. "Come on!"

"YOU KNOW HOW HIGH IT WENT? You know what that means, Nick? Sixty-six-forty-one. **SIX-THOUSAND, SIX-HUNDRED, AND FORTY-ONE FEET! ISN'T THAT SOMETHING?"**

Randy Braye and son Nick hold matching father-and-son rockets.

Seconds later, Nick says, "I think we've got a chute."

Like most high-power rockets, the Bobcat has a two-stage recovery system. Shortly after the altimeter senses that the ascent has ended, it ignites a black-powder charge that splits the rocket into two pieces (that remain connected by a nylon shock cord) and ejects a small drogue parachute. The full-size parachute will be deployed after a second charge causes the nose cone to separate when the rocket descends to a pre-determined altitude—in this case, 300 feet. At least, that's the theory.

"Nothing's coming out," Braye says glumly as he tracks the Bobcat's progress. "It's all still together. Nothing's coming out."

Meanwhile, other rockets lift off. *Whoosh*: There goes a Performance Rocket packing a J350. *Whoosh*: Wave goodbye to a homebuilt flying on a honking M1850 Green Gorilla (so called because barium causes the flame to burn green). But Braye has eyes only for his Bobcat. "Now," he whispers. "Now! Open *now*!"

Suddenly, finally, the parachute pops out. "Yes!" Braye shouts, pumping his fist. The rocket floats down under a black and orange canopy and lands in a plowed field. Braye lopes over to pick it up. By the time he gets back, his son and wife Penny are lounging in the shade. "You know how high it went?" Braye asks. He works the altimeter, which beeps in response. "You know what that means, Nick? Sixty-six-forty-one," Braye crows. "Six thousand, six hundred, and forty-one feet! Isn't that something?" Nicholas and Penny seem only mildly impressed, but Braye is too jazzed to notice. "In a half-hour," he says, "I could have this thing cleaned up, stick another motor in it, and be ready to go again."

In terms of fundamental architecture, rockets are simple devices. Load a combustible propellant in an enclosed chamber, light the fuse, and thrust is generated as the resulting gases expand, accelerating through the exhaust nozzle. The Chinese were launching rockets centuries ago with a mixture of

saltpeter, charcoal, and sulfur. Black-powder propellant is still used in modern fireworks and small model rockets. But it's an inefficient fuel, and its use stunted—literally—the growth of amateur rockets when the sport took off during the 1960s. Liquid oxygen and kerosene was a powerful alternative; after all, liquid oxygen and liquid hydrogen sent rockets to the moon. But LOX is a don't-try-this-at-home product. And while rocketeers who wanted to push the propulsion envelope used various other fuels, all were either too dangerous, too complicated, or too expensive—often all three—for widespread use.

High-power rocketry is a product of the development of so-called composite motors, which feature a witches' brew of ingredients. Known as AP motors because ammonium perchlorate serves as the oxidizer, most composites consist primarily of a plastic binding agent and a hard rubber fuel called HTPB, for hydroxyl terminated polybutadene, that is molded to fit in the motor case. Unlike their liquid-fueled cousins, solid-propellant motors don't explode in a fireball in a launch mishap. Also, composite motors provide far more bang for the buck (and ounce) than black powder.

"When I got involved, I didn't realize how many brownie points Tim would get for having a wife who flies rockets," says Beth Sapp of West Tawakoni, Texas, whose husband and two sons are avid rocketeers. "But he's created a monster. I became a high-power junkie. Now we have to fight over who's going to get to use the next big load of AP."

High-power motors are described with codes like "K550." The number is the average thrust in newtons, the force required to impart an acceleration of one meter per second squared to a mass of one kilogram (one newton equals 0.2248 pound of force). The letter rates the total impulse, or overall power, of the motor. (Dividing the total

A participant receives launch permission from a Large and Dangerous Rocket official in the form of a flight card (top). Launchers thread a guide rail through their entry's shell before mounting the rail on the pad (above left). The high thrust of the above homemade fuel grain is due in part to its star-shaped mandrel, or core.

"When I got involved, I didn't realize how many brownie points Tim would get for having a wife who flies rockets.

BUT HE'S CREATED A MONSTER.

I became a high-power junkie. Now, we have to fight over who's going to get to use the next big load of AP."

impulse by the thrust provides the duration of the burn in seconds). Each successive letter denotes a motor that is twice as powerful as the one that precedes it—a B motor is twice as powerful as an A, and a C is twice as powerful as a B (and four times as powerful as an A). A small A motor produces less than one pound of average thrust. An I motor, a common mid-power choice, might generate 50 pounds; a popular high-power M, closer to 500. Although Qs and Rs have been flown elsewhere, the largest motor at this LDRS is a P, rated at 1,800 pounds of thrust. By comparison, the Redstone that took Alan Shepard 116 miles above Earth pumped out 78,000 pounds of thrust.

Back in the 1960s and '70s, virtually all model rockets went up on black-powder motors no larger than D; there were only a handful of Es, Fs, and Gs. Sure, a few radical types clustered these motors together for additional pop. But the party line at the National Association of Rocketry was: Big is bad. So it was left to a few California renegades to challenge the status quo. One, Gary Rosenfield, later founded AeroTech Consumer Aerospace, which is now the world's largest manufacturer of hobbyist rocket motors. Another, Chuck Piper, became the chief guru of the Rocket Ranch research and development facility in a canyon near Patterson, California.

By 1981, Piper's big-iron launches in the Nevada desert were so legendary—or notorious, depending on your perspective—that past National Association of Rocketry national champion Chris Pearson flew out from Cleveland to see one for himself. "Half of the rockets blew up on the pad," Pearson recalls. "But I came home determined to put on a high-power rocket meet." The next year, he staged the inaugural Large and Dangerous Rocket Ships in Medina, Ohio.

From the beginning, the name was tongue in cheek. Nevertheless, NAR's high priests went ballistic. They excommunicated LDRS participants and declared anybody involved in high-power rocketry a heretic. And to be fair, there were big problems associated with the small community. "We had people moving from model rockets to high-power who thought they could continue to use paper tubes and white glue on wood fins," says Bruce Kelly of Orem, Utah, who edits and publishes *High Power Rocketry* magazine.

Some oversight was needed. Since NAR wasn't willing to provide it, the Tripoli Rocketry Association, which had been

The mission control team for the mighty Aurora partakes in a pre-launch interview.

formed by enthusiasts in Pittsburgh, reconfigured itself as a national organization and became the governing body of high-power rocketry. Tripoli and NAR have long since kissed and made up and have created a rigorous certification process for rocketeers who want to fly high-power motors. Generally speaking, though, NAR focuses on model rocketry, roughly defined as motors size H and smaller, while Tripoli concentrates on high-power and experimental (homebuilt) motors.

Most rockets are built from kits that must be assembled, sanded, painted, and so on. Estes dominates the entry-level market, selling small wood-and-glue kits and black-powder motors that cost as little as $3. Naturally, bigger motors require stronger airframes, typically fiberglass or a heavy-duty reinforced cardboard called phenolic. Also, higher altitudes demand more sophisticated recovery systems. A high-power rocket equipped with two parachutes and a fully equipped electronics bay can fly to 5,000 feet on an expendable J motor for less than $350. But as the motors get bigger, prices soar.

Rocket motors are built for aluminum cylinders that come in standard diameters, from 29 to 98 millimeters (about an inch to nearly four inches). The propellant is molded into fuel grains (also known as slugs or chunks), which look like spools and feel like

pencil erasers. The grains are sized to ensure an even burn, and there are usually several in each motor instead of one big one. The grains are loaded in the case like batteries in a flashlight. Close both ends, attach a graphite exhaust nozzle, and the motor is good to go. And in the 1980s, once it went, it was gone for good.

Enter the reusable motor. "I knew motors would cost a lot less if we could just sell the part that burned off—the fuel grains," Rosenfield says. "And I felt that people would enjoy putting their motors together." Aluminum cases last forever if they're not lost or damaged in a CATO, which rhymes with "Playdough" and is short for "catastrophic failure." The hardware for a 54-millimeter (two-inch) motor like the one the Bobcat uses is about $60. But Braye's principal cost per flight is the reload kit, which runs $90.

LDRS isn't the Promised Land for amateur rocketry extremists: That would be Black Rock Desert in Nevada, where Tripoli holds an annual National Experimental Launch. But the LDRS offers more variety than any other gathering.

Of the 1,200 rockets launched during six days of flying, 37 go up during a single high-power drag race. Solo launches include a model of The Big One featured in the movie *Toy Story* and an even bigger model painted in black and white blotches and named *Udder Madness*. (Alas, it CATOs on the pad.) One joker lights off a rocket made of cardboard packing material secured with Postal Service tape. Another flies a rocket made of Legos. Ky Michaelson goes both of them one better. The self-proclaimed Rocket Man, who built 13 rockets for the celluloid paean to amateur rocketry, *October Sky*, flies a Porta-John on a pair of M500s.

After several failed attempts, a group from Dallas launches a quarter-scale model of NASA's never-flown X-30 lifting body. It's one of a small number—perhaps five percent—of the rockets flying at LDRS with a hybrid HyperTEK binary-fuel motor. Although hybrids are disparaged as "farting rockets" because of their flatulent roar, they're less expensive than the more closely regulated AP motors. (And after 9/11, the Bureau of Alcohol, Tobacco, Firearms, and Explosives wants to clamp down even more on AP, which it classifies as an explosive.) Barry Lynch, owner of LOC/Precision, a leading mid-range kit maker, says: "I think hybrids are the wave of the future." After the X-30's HyperTEK stops passing gas, its pilot Dave Schaefer takes over the radio controls and greases the landing.

The last two days are devoted to experimental rocketry—the homebuilt motors. Composite propellant isn't particularly difficult to whip up in home labs. But the process demands a substantial amount of time, space, equipment, supplies, patience, and precision. Bob Brown, vice president of Kloudbusters, the Tripoli chapter sponsoring LDRS XXII, explains: "We say that we save money by flying experimental motors, but that's not true. We spend the same amount of money. We just fly bigger motors."

Besides being cheaper than their commercial counterparts, experimental motors can be designed to achieve specific

A Hobby Lab radio-controlled SR-71 model with a D-size motor will get up to about 100 feet; an F or G will take it 10 times higher. The smaller Estes and Quest rockets in the foreground use A to D motors.

goals. "They give you more flexibility," says Jeff Taylor of Milford, Connecticut, who runs Loki Research and hosts how-to seminars all over the country. "You can tailor the thrust performance to your needs. For higher altitudes, you want a longer burn. For a booster that's part of a two-stage rocket, you want to accelerate as fast as possible. You can even adjust the color of the flame." And rocketeers like color, which is why they add sodium to produce an orange flame, strontium for red, magnesium for white, and titanium chips for sparks. "It's all about fire, smoke, and noise," Rosenfield says.

Taylor has machined a lot of the hardware that is used in the motor of LDRS's star attraction, the Aurora. The immaculately finished, 20-foot-tall, carbon-fiber body shrouds sophisticated avionics and telemetry systems, a camera, and the gargantuan P motor, with 1,800 pounds of thrust derived from 50 pounds of Polish Rojo, a wicked homebrew made by motor builder Pat Gordzelik of Canyon, Texas.

The Aurora is the brainchild of Gordzelik and Dan and Terry Stroud, father and son, both of whom live in suburban Dallas. And even though they've been planning to fly it for months, the project turns into a last-minute thrash. Work continues until 3:30 a.m. Monday, and the rocket isn't hauled out on a flatbed trailer to the remote launch pad until after 9 a.m. The FAA waiver is only eight minutes from expiring by the time the launch control officer finally pushes the ignition button.

Look familiar? It's a supersized copy of Buzz Lightyear's vehicle of choice in Toy Story.

Burn, baby, burn: The 20-foot Aurora achieved Mach 1.81 in its climb to nearly 30,000 feet.

For what seems to be an eternity, nothing happens. The crew members huddled near the launch pad are deathly silent. The Aurora finally lights, but still the crew says nothing; this is when a CATO is most likely. The rocket launches at a slight angle, and the crew holds its collective breath.

Then the fins right the Aurora's trajectory, and the rocket arrows straight up at Mach 1.81. The crew is still silent, but now with awe. It isn't until the rocket is a tiny speck in the sky that the cheering commences. "Oh my God!" Dan Stroud says. "Holy cow! That is awesome!"

The burn lasts 7.81 seconds, and the rocket doesn't run out of momentum until reaching 29,985 feet. A handful of amateurs have just sent a homemade object five and a half miles into the atmosphere and retrieved it, no worse for the wear, after a 28-minute flight.

"I'm not comfortable calling what we do a hobby," says Kimberly Harms of Quilcene, Washington, who has her own crew of high-power rocketeers. "A hobby is fun. Well, we don't come out here in 110-degree heat to fly rockets just for fun. This is a mission."

The immaculately finished, 20-foot-tall carbon-fiber shell shrouds sophisticated avionics and telemetry, a camera, and a gargantuan P motor with 1,800 pounds of thrust derived from 50 pounds of Polish Rojo, a wicked homebrew.

THE FAA WAIVER IS ONLY EIGHT MINUTES FROM EXPIRING WHEN IT FINALLY LAUNCHES.

The National Air and Space Museum's Steven F. Udvar-Hazy Center

More to see, more to do, more to learn

The Smithsonian Institution first started collecting items related to flight in 1876, when the Chinese Imperial Commission donated a small selection of kites. Now, 127 years later, the National Air and Space Museum holds in trust 325 aircraft, 30,000 aviation artifacts, 9,000 space artifacts, 4,252 pieces of aviation art, 1.75 million aviation and space history images, 44,000 reference books, over 300,000 photographs of the planets and their satellites, and one genuine Space Shuttle.

It's no wonder that the National Air and Space Museum, which has been jokingly called the "Air and No Space Museum," is bursting at the seams. "We have the largest and most complete collection in the world, but the public has been deprived of its full benefit," said Gen. John R. "Jack" Dailey, director of the National Air and Space Museum. "To comprehensively explore the history, science and technology of flight, it takes a lot more room than we could ever have on the Mall."

The idea of building an annex to the world's most visited museum had been tossed around for decades. But lack of funding always held things up—until now. On December 15, the National Air and Space Museum ushers in a new era when its spectacular new companion facility, the Steven F. Udvar-Hazy Center, opens its doors to the public.

The Future Takes off from Here

"This is the perfect way to launch the Smithsonian into the twenty-first century," said Lawrence M. Small, secretary of the Smithsonian Institution.

Located at the southeastern corner of Washington Dulles International Airport in northern Virginia, the Udvar-Hazy Center provides enough space to display artifacts that have been in storage or on loan for decades, plus those too large to display at the flagship building in Washington.

The aviation hangar is reminiscent of the gigantic hangars used in the past to house Zeppelins. Three football fields long and ten stories high, it is large enough for nearly 200 aircraft and hundreds of small aviation artifacts, with ceiling arches capable of holding 20,000 lbs. (9,000 kilograms). "We like to think of it as the Nation's Hangar," Dailey said.

MARK AVINO

Sunset over the Udvar-Hazy Center. The Donald D. Engen Observation Tower and the sculpture Ascent *are in the foreground.*

A second hangar houses the Space Shuttle *Enterprise* and will be home to 135 other space treasures that ultimately will be displayed there. In addition, there is a soaring 164-foot observation tower with views of all the runways at Dulles; an IMAX® theater; state-of-the-art education facilities; and, eventually, a restoration hangar and archive facilities.

All told, the Udvar-Hazy Center is approximately 760,057 square feet (70,611 square meters) in size, with plenty of room for expansion as the air and space advances of the twenty-first century are added to

With the opening of the Udvar-Hazy Center, the National Air and Space Museum becomes the largest museum of its kind in the world.

Although the move-in is not anywhere near complete, upon opening, the Udvar-Hazy Center will have more aircraft on display than the museum on the Mall.

the collection. "A more important number to consider is 40 million cubic feet, because that means we have an unbelievable amount of volume to make use of," Dailey said. "We are using that volume to hang airplanes from the ceiling."

The new building is an attraction in itself. Besides being huge, it offers the latest in twenty-first century design concepts. Bill Hellmuth, architect, said his principal goal was to create a building as interesting as the artifacts themselves. The building looks and feels as if it belongs at an air terminal. The entrance is designed to look like an arrival and departure area, the main section like an airplane fuselage.

CAROLYN RUSSO

Interior view of the Udvar-Hazy Center, July 2003: Many of the artifacts are wrapped in plastic for protection before opening day.

Another goal of the design was to allow people to experience the relationships of scale that are inherent in displaying artifacts of this size. "I think people will enjoy this experience because it is something they're not accustomed to seeing every day," Hellmuth said.

Yet another special aspect of the design is a lack of exhibit galleries like you see at most other museums. Instead, imagine a huge, unobstructed space with aircraft displayed on three levels. Larger aircraft rest on the floor, where you can walk among them. Smaller aircraft hang from the steel trusses, giving the appearance of a sky full of aircraft flying in all directions. Forty-foot-high skywalks bring you nose-to-nose with the "flying" machines and offer impressive panoramic views of the entire hangar.

Seeing the Udvar-Hazy Center for the first time is a jaw-dropping experience. "Whenever I bring people here, they just stand there in awe of the place," said Lin Ezell, project manager for the facility. "The most-often-used words I hear are, 'Awesome!' and 'Wow!' "

The aviation hangar is organized with military aircraft on the north side and civil aircraft on the south. Visitors enter onto the second floor near the center of the building. Straight ahead they see the dramatic and familiar lines of the Space Shuttle *Enterprise* in the Space Hangar.

Ten thematic exhibit stations are placed throughout the center. The exhibit stations anchor aircraft or spacecraft according to these themes, and the hanging artifacts relate to the stations and other aircraft on the floor. The themes are:

- Business Aviation
- General Aviation
- Commercial Aviation
- Sport Aviation
- World War II Aviation
- Cold War Aviation
- Korean and Vietnam War Aircraft
- Modern Military Aviation
- Space Hangar Preview
- Pre-1920 Aviation
- Vertical Flight (2004)

Although "big" is the essence of the Udvar-Hazy Center, thousands of small artifacts finally have their day in the sun too. New display cases were designed by museum staff specifically for these collections. "I think visitors are really going to enjoy these smaller items going on display for the first time," said museum curator Dorothy Cochrane. "We have collections of aerial cameras, airplane machine guns, uniforms and Lindbergh memorabilia, to name a few."

Another "first" is having so many of the surviving gems of this nation's early rotorcraft heritage displayed in one place, most of which has been in storage for years. "Only 18 percent of our rotorcraft have been on display in the building on the National Mall," said Roger Connor, curator

ERIC LONG

Model of the Sikorsky VS-300 helicopter.

in the Aeronautics Division. The collection contains many spectacular rotorcraft that have proven to be major milestones for the industry.

Because this is such a huge, complicated undertaking, the center will open in phases. The initial phase was timed to coincide with the centennial of the Wright brothers' first powered flight. This phase includes the opening of the aviation and space hangars, the observation tower, IMAX® theater, education center, museum store, and food court. Artifacts will continue to be moved into the center over the next few years, making it a new experience for visitors each time they visit. Although the space hangar is complete, it will not officially open until mid-2004. In the meantime, visitors can see the *Enterprise* from the aviation hangar, as museum staff clean the craft and prepare it for display.

CAROLYN RUSSO

A restoration specialist covers the de Havilland Super Chipmunk in plastic at the Udvar-Hazy Center.

Subsequent phases, dependent on funding, include the restoration hangar, object processing and study collection facilities, archives, conservation labs, and support buildings. "We are really anxious to get the restoration hangar up and running," said Ezell. "It will let people see how we preserve and restore our artifacts, putting what is usually a behind-the-scenes activity in full view of the public."

More to See

"Nowhere will you see a collection as complete as this, and displayed in such a unique way," Dailey said with pride. A few of the artifacts on display at the Udvar-Hazy Center are:

The de Havilland Super Chipmunk

The de Havilland Super Chipmunk was originally designed as a post-World War II primary trainer. Among the many pilots who flew the Chipmunk for pleasure was veteran aerobatic and movie pilot Art Scholl. He thrilled audiences flying his modified Chipmunks at air shows around the country through the 1970s and early 1980s. He worked on such movies as *Top Gun* and *The Great Waldo Pepper*, plus the TV series "Baa Baa Black Sheep." His cameras have also been donated to the museum and will be exhibited in the aerial-camera case.

ERIC LONG

The Curtiss P-40 Warhawk suspended from the trusses of the Udvar-Hazy aviation hangar.

How Did They Do That?

Q: How did you move all these airplanes?

A: First the aircraft were cleaned, inspected and disassembled. Special cradles were built to support the fuselage sections. For the larger aircraft, a forklift positioned the cradle and airplane high enough for a flatbed truck to be backed under them. Smaller airplanes were loaded into big rigs. Once the cradled fuselage and other pieces were on board, heavy chains were used to secure them in place, and the aircraft were trucked on the highways between Suitland, Maryland, and Chantilly, Virginia, usually in the very early, dark hours of the morning. "It's much more complicated and time-consuming than this, but that's the process in a nutshell," said Al Bachmeier, museum specialist. The Collections staff estimates they will spend 15,599 hours to pack and move the artifacts just for Stage One (opening day).

Q: How did you figure out where to put everything?

A: First, a variety of reference materials was used to get enough information to make scale drawings of each artifact. With these, William "Jake" Jacobs from the Exhibits Division was able to create computer drawing files for the artifacts. These drawings were combined with building drawings provided by the architect, using AutoCAD® (Automated Computer-Aided Design) software. The drawing files from AutoCAD® were used to drive a router that cut out scaled two-dimensional models from 1/8-inch-thick plastic. These cutouts were arranged by curators in a scale model of the Udvar-Hazy Center to get a three-dimensional view of how everything should fit together. Thus, physical and computer models were available for the movers and riggers come move-in day.

Estimates call for three million visitors a year at the Udvar-Hazy Center in addition to the over nine million who visit the Mall site.

The building on the Mall was America's gift for the nation's bicentennial, and the Udvar-Hazy Center is America's gift for the centennial of flight.

McDonnell F-4S Phantom II

Some aircraft are remembered for the large number produced, others for their length of time in service, and others for their ability to perform their mission. The McDonnell F-4S Phantom II is known to be one of the leaders in all three categories. In 1968 the Navy chose the F-4J for its Blue Angels team and in 1969 the U.S. Air Force chose the F-4E for its Thunderbirds team. The United Kingdom, Iran, South Korea, Spain, Australia, Israel, Japan, Greece, Turkey, and Germany bought McDonnell F-4s in large numbers.

Gemini VII

NASA launched Gemini VII on December 4, 1965, the third in a series of long-duration missions that would demonstrate capabilities necessary to reach the Moon in Project Apollo. Frank Borman served as command pilot and Jim Lovell as the pilot. Borman and Lovell not only studied the long-term effects of spaceflight but also rendezvoused in Earth orbit with Gemini VI, another skill critical to completing Apollo. Altogether Gemini VII remained in orbit for 14 days, completing 220 orbits.

ERIC LONG

The Gemini VII capsule. This mission was the longest U.S. spaceflight until Skylab.

Junkers Ju 52/3m

ERIC LONG

The Junkers Ju 52/3m carried up to 17 passengers, or about three tons of freight, and cruised at about 150 mph. It could take off from or land on almost any reasonably sized field, even a football field.

Junkers Ju 52/3m (CASA 352L)

This tri-motor passenger plane was designed in Germany and built in the 1930s. It became one of the best-known European transport aircraft in history, and the one produced in the greatest numbers. The German flag carrier, Deutsche Luft Hansa (D.L.H.), had more than 200 of them, and it was so loved by its pilots they affectionately called it "Tante Ju," or "Aunt Ju."

Bell UH-1H Iroquois

What the jeep was to Americans during World War II, so was the Huey to those who fought in Vietnam. All branches of the U. S. military operated them, and they ranged to every corner of South Vietnam and into Cambodia and Laos. The term "Huey" originated in the U. S. Army as a derivative of the original designation HU-1A: Helicopter, Utility, model 1A. For a time, the Huey was one of the most recognizable aircraft in history. People knew it not just on sight but by sound. They heard the unmistakable *whop-whop-whop* of the main rotor blade long before they saw the Huey.

You can read about more aircraft destined for the Udvar-Hazy Center on our map on page 41. For complete information on all the artifacts going into the center, please visit: http://www.nasm.si.edu/museum/udvarhazy/artifacts.cfm

More to Do

Bring your binoculars and watch airliners from all over the globe take off and land at Dulles Airport.

Try your hand at landing aircraft at the interactive air traffic control mock-up.

Strap yourself into a flight simulator and pilot through a twisting 360-degree aileron roll or pull back on the joystick to complete an upside-down loop.

Experience the thrill of a large-screen IMAX® movie.

Take a guided tour.

Shop in the museum store.

Take time out for lunch; food is available on the first and second levels.

The Bell Tiltrotor XV-15 makes its final landing at the Udvar-Hazy Center.

Then—take the shuttle bus to the Mall and see even more of the greatest icons of aviation and space.

More to Learn

With the museum expansion, the National Air and Space Museum will have many more opportunities to complete the "educate and inspire" portions of its mission. From the beginning of the design process, the education facilities at the Udvar-Hazy Center were given special attention, and students all over the country will be able to benefit from these brand-new, state-of-the-art facilities.

One of the most exciting new developments is the "Teacher-in-Residence" program. Three teachers, from Virginia's Fairfax and Loudoun School Districts and the Potomac School, have been loaned to the Udvar-Hazy Center full-time for an entire year. These teachers will assist with the development and presentation of school programming based on the Virginia State Standards of Learning and the collections of the National Air and Space Museum. They will create teaching plans, building a bridge between the school curriculum and the center's collections. The Teacher-in-Residence program provides needed staff and curriculum support to the Udvar-Hazy Center, while the schools gain a teaching resource well versed in the resources of the National Air and Space Museum. Their respective school districts have generously agreed to pay the salaries of the teachers while they are in residence.

But the center's educational reach goes far beyond Virginia. The new center has three classrooms, two traditional and one laboratory, with full multimedia capabilities. Students from all over the country can make virtual visits to the museum, participating in distance learning through their school's satellite hook-up.

Tours for student groups will be first-rate. More than 500 people applied to be volunteer docents leading these tours! With such a large pool of applicants to choose from, and the intensive training they were given, the center's docent team is one of the finest anywhere.

The center is named after Steven F. Udvar-Hazy, President and CEO of International Lease Finance Corp., who launched the project with a donation of $60 million and later pledged an additional $5 million.

Boeing 367-80

The Boeing 367-80 (Dash 80) is one of the aircraft appearing on an Education poster designed to illustrate the way wings work. Each aircraft on the poster was chosen for its wing shape and design.

The Interactive Discovery Stations so popular at the flagship building on the Mall will be available at Udvar-Hazy as well. The stations in place so far include:

- Principles of Flight
- Inventing Flight
- Air Transportation Past, Present and Future
- Living and Working in Space

The Udvar-Hazy Center features other interactive activities, such as the Great Paper Airplane Contest. It also hosts numerous special events throughout the year. Please visit the National Air and Space Museum's web site for a schedule and other information about educational activities available: http://www.nasm.si.edu/education/overview.cfm

Some highlights and a map of the National Air and

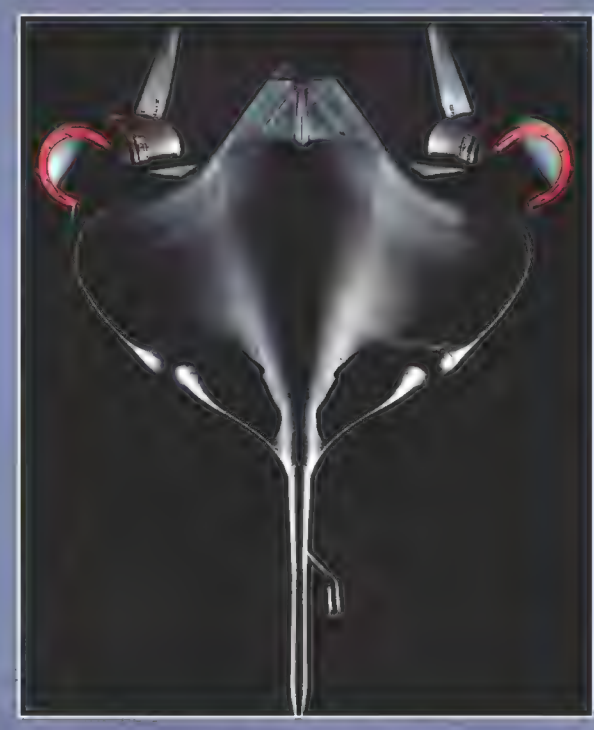
The B-29 Superfortress *Enola Gay*: Fully restored and in one piece for the first time in nearly 40 years. It dropped the first atomic bomb during World War II.

Boeing 307 Stratoliner: First commercial airliner to use pressurization, a technology that allowed it to fly over weather. Designed in the 1930s.

Republic P-47D Thunderbolt: Nicknamed the "Jug," the heaviest single-engine fighter of World War II. It was produced in greater numbers than any other U.S. fighter.

Space Shuttle *Enterprise*: From 1977 through 1979, NASA used the *Enterprise*, the first shuttle, for approach and landing test flights in the atmosphere as well as vibration tests and launch pad fit checks on the ground.

Northrop N-1M Flying Wing: The first flying wing airplane with cockpit, engine, and fuselage integrated in a basic airfoil envelope.



Lockheed SR-71 Blackbird: Fastest jet in the world—ever. On its final flight, in 1990, it flew from Los Angeles to Washington, D.C., in 1 hour, 4 minutes, and 20 seconds, averaging 2,124 mph (3,418 kph).

BAC/Aerospatiale Concorde: The only Western supersonic jet ever put into service. Began flying commercially in 1976. Air France and British Airways were the only airlines to fly them.

Space Museum's new Steven F. Udvar-Hazy Center

Facts for Your Visit

ERIC LONG

An aerial view of the Udvar-Hazy Center taken before the facility was completed.

The National Air and Space Museum's
Steven F. Udvar-Hazy Center
Air and Space Museum Parkway
Chantilly, Virginia
(202) 357-2700, (202) 357-1729 (TTY)
www.nasm.si.edu/museum/udvarhazy/

Round-trip shuttle bus service is available between the building on the National Mall and the Udvar-Hazy Center. The cost is $7 per person.

Parking is available for 2,000 cars at $12.00 per day.

Welcome Center: Just on the right inside the front entrance, on level two.

Tours: Walk-in highlights tours are offered daily at 10:30 a.m. and 1:00 p.m.

Live demonstrations are offered at various times throughout the center.

Photography: Hand-held and home video cameras are permitted; tripods are not.

Where to eat: Food service is located on levels one and two of the center.

Museum Store: The Museum Store, offering a variety of flight-related merchandise, is located on level two.

IMAX® Theater: Daily showings of large-format films are presented on a giant screen. Tickets can be purchased online at www.smithsonian.org/IMAX®

To make your visit more enjoyable, please wear comfortable, rubber-sole shoes, as the floor is not carpeted.

Directions to the Udvar-Hazy Center:

From Washington, D.C., and points south: I-66 West to Route 28 North (Exit 53B): Travel on Route 28 North for 5.3 miles. Exit at Air and Space Museum Parkway and follow the signs to the Udvar-Hazy Center.

From Washington, D.C., and points north: I-495 South (Capital Beltway) to the Dulles Toll Road West (Route 267). Exit the toll road at Route 28 South (Exit 9) and travel south 3.5 miles. Exit at Air and Space Museum Parkway and follow the signs to the Udvar-Hazy Center.

From the west: Take the Dulles Greenway to Route 28. Exit at Air and Space Museum Parkway and follow the signs to the Udvar-Hazy Center.

National Mall: The National Air and Space Museum
6th St. and Independence Ave., SW
Washington, DC
(202) 357-2700, (202) 357-1729 (TTY)
Nearest Metro Stop: L'Enfant Plaza
www.nasm.si.edu

Help Support the Udvar-Hazy Center and Be a Part of History Too

Place your name on the Wall of Honor, next to some of history's most famous air and space explorers, like the Wright brothers, Charles Lindbergh, Amelia Earhart, and John Glenn. The Wall of Honor is a permanent memorial to those who have contributed to aviation and space history, or those with a passion for flight. To put a name on the Wall of Honor, follow the registration instructions on the museum's web site:
www.nasm.si.edu/wallofhonor
or call: 202-633-2606
or e-mail: wallofhonor@nasm.si.edu
Minimum donation is $100 and is tax deductible.

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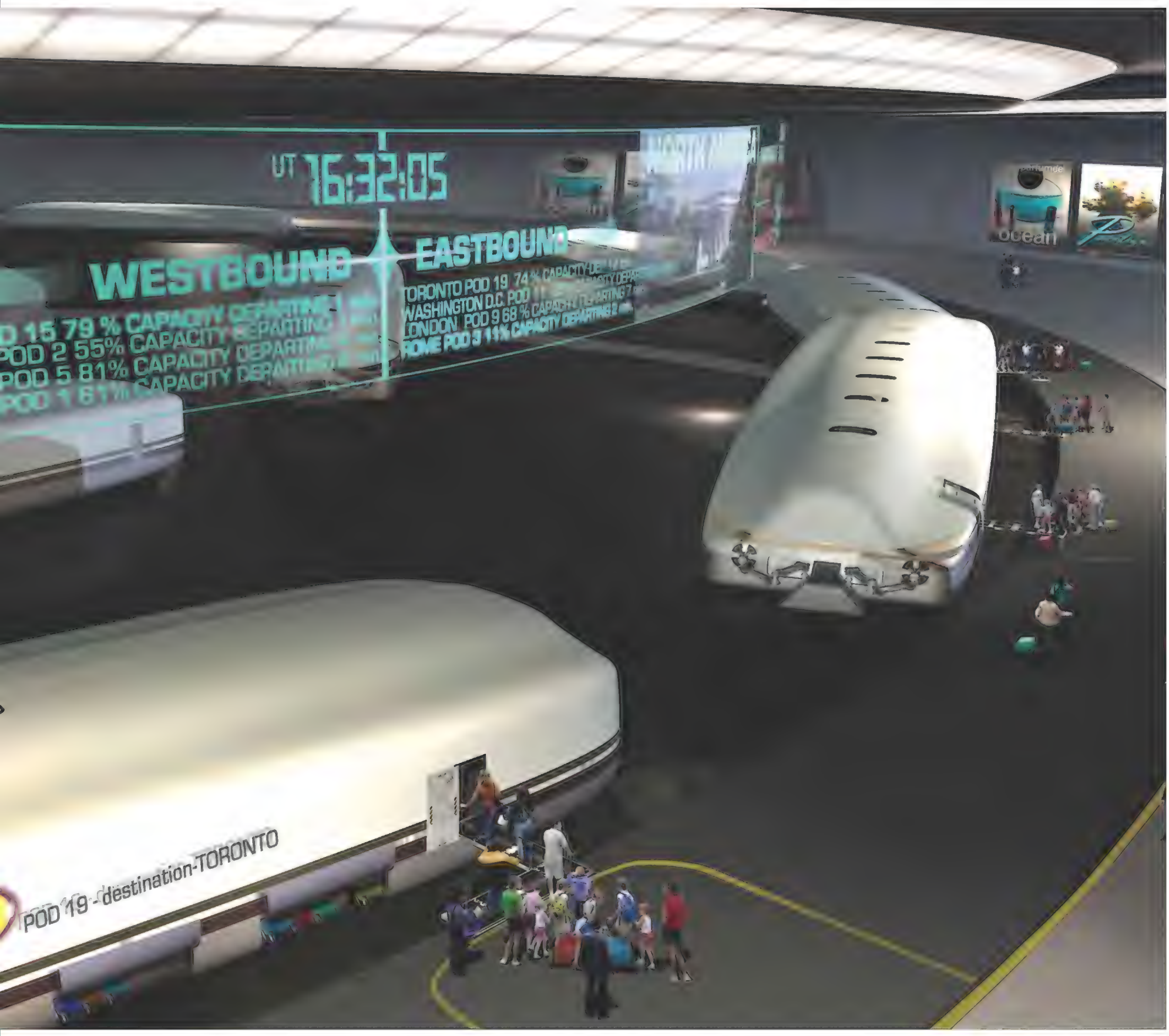
TURNTABLE BOARDING AND CAT LAUNCHES

>> We'd come across the water from San Diego in a shuttle train, watching the red navigation lights of Global Clippers appear in the dark southwestern sky and then disappear at the horizon. At dawn, we got the first glimpse of our destination—the still-unopened terminal of Neil A. Armstrong Intercontinental Airport. As our shuttle slid silently past the imposing domed structure and came to a stop between the towering cement haunches of the runway pier, airport architect Lakshmi Prasad stretched and stepped off the train into



a corridor filled with sea air.

"Box that one back up!" she yells to a group of workers unwrapping a hideous sculpture donated by a prominent West Coast family. The men laugh and ask if she's giving yet another dime tour of the airport. "Well," she replies, "he is only here for one day."

Completed just days ago, in time for a December 3 opening, but $52.6 trillion over budget, the mammoth island airport was active this morning as part of a 48-hour test of its integrated, automated guidance system. Two dozen Global Clippers were shuttling back and forth on programmed routes over the Pacific, each with a flight computer loaded with software designed to tax the IAGS with a different hypothetical problem. Collectively, all this data would create a landing pattern logjam that the airport's computers would have to repeatedly sort through safely, and all of this at the whim of wind direction and the pilots hired to run occasional interference with lumbering span-loader transports. Armstrong's management hopes to receive passengers on the 17th–powered flight's 200th anniversary–and will bring aerospace bigwigs and governmental officials to a much ballyhooed opening event.

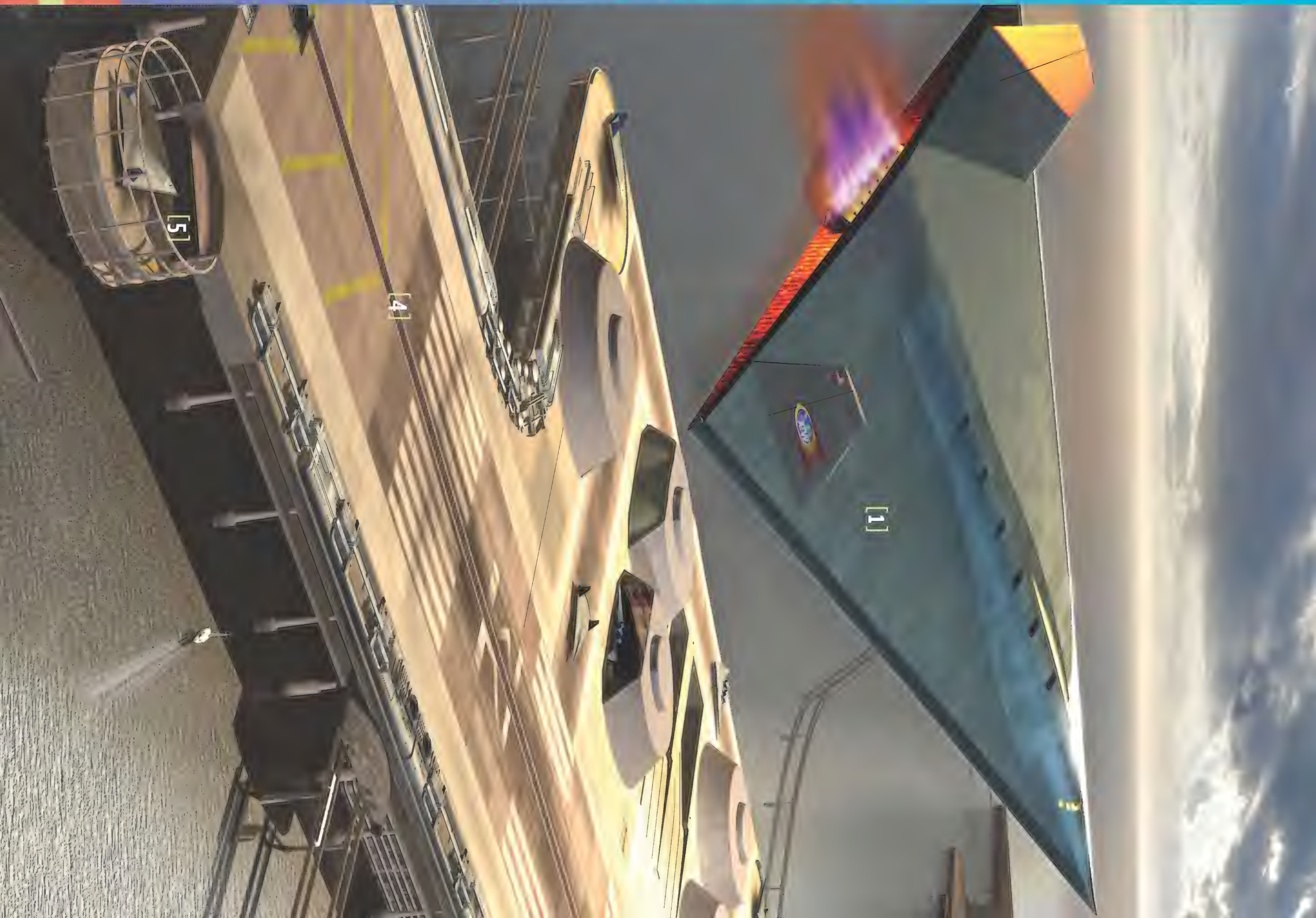
"I'm happy that I don't have to plan that too," jokes Prasad. Since she was nominated for the project in the early '90s (Soundings, Apr./May 2091), she's endured oversight from Congress and the Federal Aviation Administration–Armstrong is 65 kilometers off the southern California coast, beyond the reach of state law–as well as International Civil Aviation Organization scrutiny. She has spent the past decade designing the airport: overseeing the grooming of the ocean floor for construction, analyzing wave and wind direction, and managing the construction of the terminal that will set Armstrong architecturally and operationally apart from other Clipper-serviceable airports.

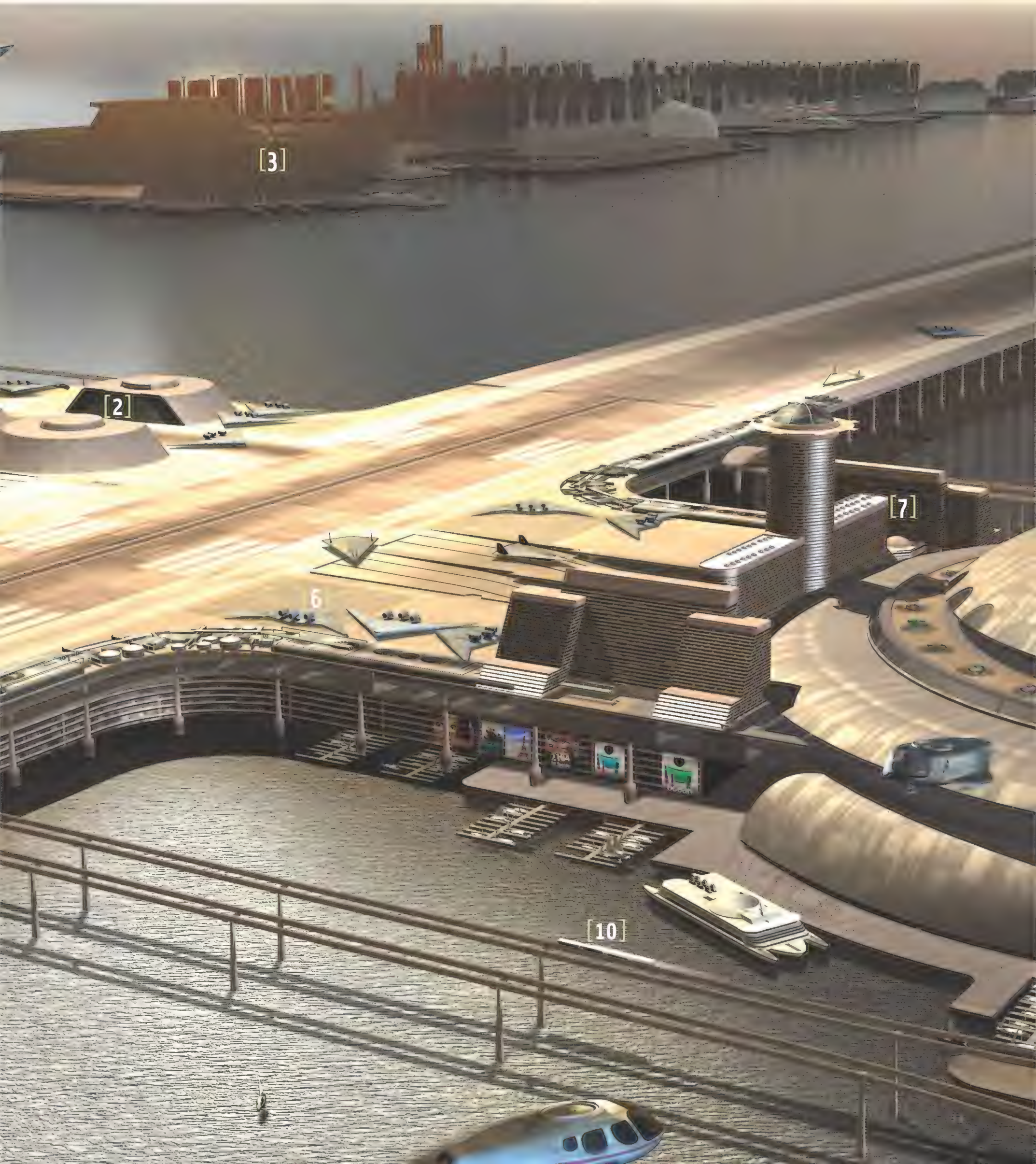
THE CAROUSEL: ARMSTRONG'S UNIQUE SLOW-TURNING BOARDING DECK ALLOWS TRAVELERS TO STROLL INTO ONE OF UP TO 22 PODS.

At the terminal's heart–under the knobby rooftop communications center and the arboretum, over the shopping area, which dips 20 levels and 100 meters below the surface, and surrounded by docks and levels of parking for personal air vehicles–is a 15,000-square-meter turntable, the boarding area affectionately called the Carousel.

(*continued on page 8*)

>> Neil A. Armstrong Intercontinental Airport

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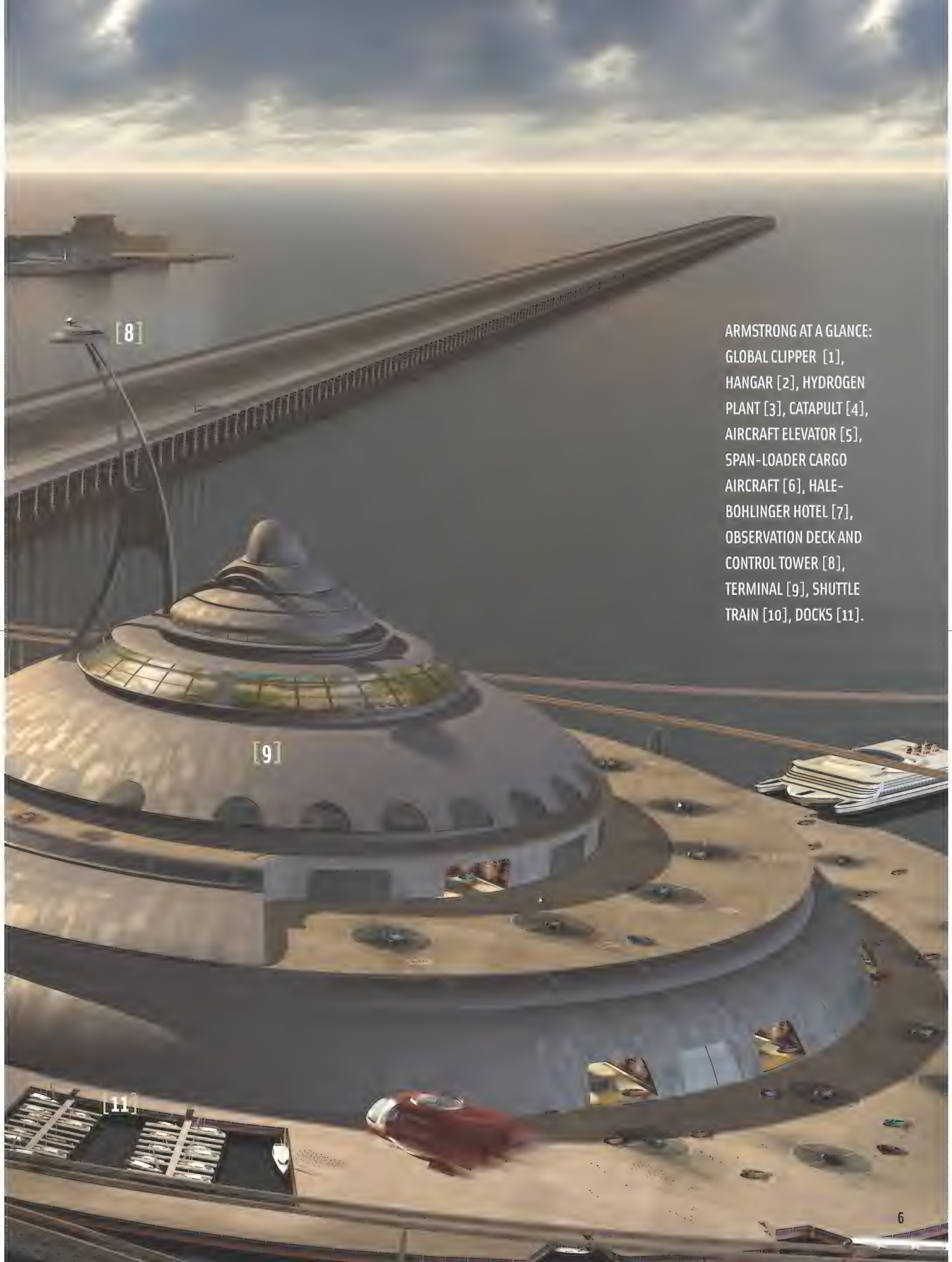


ARMSTRONG AT A GLANCE: GLOBAL CLIPPER [1], HANGAR [2], HYDROGEN PLANT [3], CATAPULT [4], AIRCRAFT ELEVATOR [5], SPAN-LOADER CARGO AIRCRAFT [6], HALE-BOHLINGER HOTEL [7], OBSERVATION DECK AND CONTROL TOWER [8], TERMINAL [9], SHUTTLE TRAIN [10], DOCKS [11].

Airport >> Features

THE HALE-BOHLINGER HOTEL >> Flanked by two 29-story hotel towers, the Armstrong Hale-Bohlinger's 50-story central structure houses 25 meeting rooms, six convention hall levels, an indoor/outdoor swimming pool, and a rotating rooftop restaurant. The 850-room hotel is capable of hosting 2,750 guests per night.

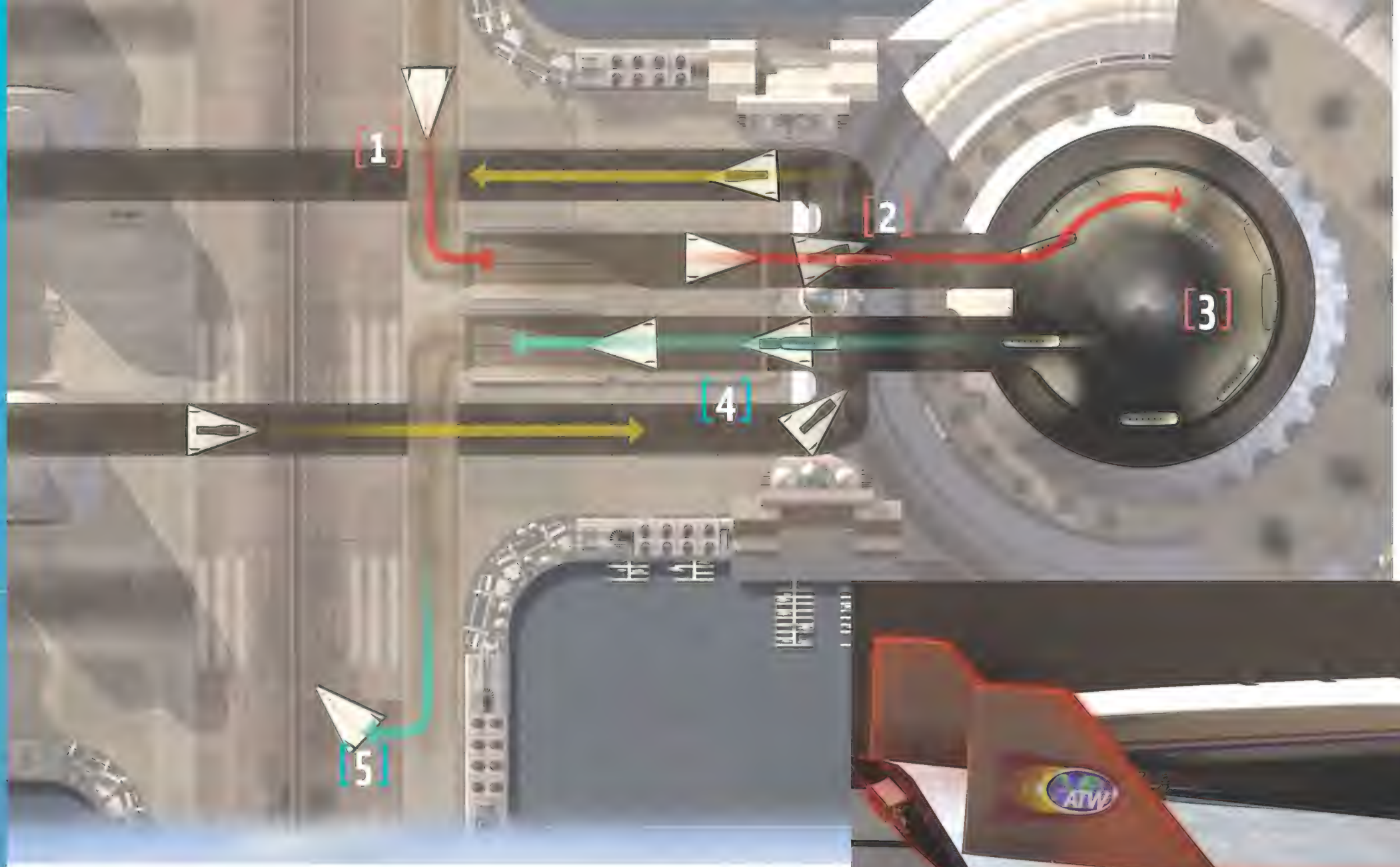
TERMINAL PEAK >> A radio-transparent enclosure protects antennas, satellite dishes, phased-array-radars, and other communications equipment atop Armstrong's terminal. The arboretum, located several levels below, is home to lizards, insects, and 21 species of birds native to southern California, as well as regional trees and shrubbery and a simulated meadow/picnic area.

THE PARKING SITUATION >> Public skybuses and air taxis will offer service to and from the California and Mexican coasts and Santa Catalina island. Parking circles for larger group and tour transports are outside the terminal, separate from the internal kiss-and-fly zone, in order to reduce traffic congestion. Airport patrons can choose to leave their personal air vehicles in one of the 1,500 spaces for long- and short-term parking inside the terminal.

CONTROL TOWER/OBSERVATION DECK >> Reaching 300 meters above the water, the two-level control tower houses an emergency command center and an observation deck for visitors. Should the integrated, automated guidance system fail, air traffic controllers could run the airport from the upper level. On the lower deck, sightseers can enjoy a 360-degree view of the airport.

AIRCRAFT ELEVATORS >> At roughly an acre in area each, Armstrong's aircraft elevators are the largest ever built. Each of the four elevators is capable of lifting 4.7 million kilograms the 30 meters between the runway and the maintenance deck in 25 seconds.

SPAN-LOADER CARGO AIRCRAFT >> Armstrong will be a West Coast hub for aerial shipping. Span-loader cargo craft—so called because they generate lift over the entire span of their bodies—will make scores of daily trips to and from the airport, using much of the 4.25-kilometer-long runway to gain speed for takeoff. Though high-powered and designed for low wing loads, span-loaders must still battle the inertia of enormous payloads to get into the air.



WHEN A CLIPPER ARRIVES AT THE TERMINAL [1], ITS PASSENGER POD SEPARATES [2] AND IS PLACED ON THE CAROUSEL [3]. AFTER DE-PODDING AND BOARDING, THE POD IS MATED TO A REFRESHED CLIPPER SHELL [4] AND HEADS TO THE CATAPULT [5] FOR TAKEOFF.

(*continued from page 3*)

"There's really nowhere left on the [California] coast that could have accommodated this," says Prasad. "This site was a gift. I didn't have to worry about the environmental footprint of the project, which has constrained other designs." Clipper-serviceable airports have been built along coastlines to keep the aircraft's intrusive sonic booms over water and away from inland homes, but coastal land is expensive, and laws designed to protect fragile coastal ecosystems restrict land use to narrow swaths that force designers to utilize boarding systems similar to old rail terminals: passenger pods arrive along a straight track and exit along the same route to awaiting Clipper shells.

Prasad's Carousel is based on a new philosophy. Its wide disk slowly carries pods plucked from arriving Global Clippers along its circumference. From there, passengers de-pod onto an outer platform. When the pod has been emptied, it is designated for another destination and travels along the Carousel's rim and fills with passengers. Pods continue along the Carousel until the scheduled departure time, then are sent to the exchange ramp and mated with Clipper shells. If a pod's capacity is reached before the departure time, the pod is sent to the ramp and a supplemental pod is brought to the line. "The only limit on destinations here is how many pods can fit along the circumference," says chief engineer J. Brent Andrews.

"We can fit 22 pods along the rim—enough to ensure that at least one pod will head toward each Clipper-accessible destination per 90-minute window," adds Prasad as we take an elevator to the airport's apex—a control tower and observation platform that reaches 300 meters above the water. It was added late in the project at the insistence of the FAA in case the IAGS fails. Supported by an elegant arch ("I did the best I could to reconcile it with the already existing design," apologizes Prasad), it will be lightly staffed unless there is an emergency, though it offers travelers a better glimpse of glowing Clippers returning from the stratosphere, panoramic views of the towering photovoltaic power cells in the hydrogen plant two kilometers away, and a God's-eye view of diners at the hotel's glass-domed rooftop restaurant.

AFTER SEPARATION FROM PASSENGER PODS, CLIPPER SHELLS TRAVEL BY TUNNEL TO THE MAINTENANCE DECK, WHERE THEY ARE INSPECTED FOR MECHANICAL PROBLEMS AND SCANNED FOR CRACKS AND TEMPERATURE ANOMALIES. IF ALL GOES WELL, SHELLS ARE REFUELED AND READY FOR NEW PODS IN 25 MINUTES.

Later, down on the seaport level ("Clearly the best part of the place," says Prasad), the architect points to some of the small roman numerals construction crews painted on the edge of the terminal roof when they realized that the gnomon-like control tower created a grand sundial. Franklin Xiao, Armstrong's passenger experience overseer, shares Prasad's enthusiasm for the seaport level. "We've got several ways for delayed or anxious travelers to calm their nerves," he says. Among options open to airport patrons: taking a waterside stroll, renting a boat, and fishing on a small pier.

The construction of the seaport was subsidized by

the gambling and cruise industries, which believe Armstrong to be an ideal jumping-off point for offshore betting and vacations in the Pacific. Though Armstrong will collect billions of dollars annually in fees from cruise lines and casinos, about a quarter of the revenue from water traffic will be generated by leasing space to smaller boats. "Most of the interest we've seen has been from deep-sea fishing outfits who would save on fuel costs by keeping their boats out at sea rather than in a coastal harbor," says Josh Huisenga, Armstrong's business manager. But fishermen won't have to travel far for good waters; the complex's pylons have been seeded with coral to catalyze a lively ecosystem.

So as not to scare away fish or hotel guests, the extraordinarily loud hydrogen-powered catapult used to launch Global Clippers is muffled by a state-of-the-art black-sound speaker system. It should be an upgrade over earlier models notorious for allowing occasional claps and hisses to escape and stress buildings at other airports—most notably causing the collapse of a storage silo at McKenzie Airport in Vancouver two years ago.

But on the maintenance deck 30 meters below the runway—where muffling is supposed to have the greatest effect—it's clear the system still has bugs. Employees of an entertainment company using the space to set up for the airport's grand opening had learned to recognize the purr at the start of the catapult sequence, and periodically rushed to strap on earmuffs to insulate themselves from the booms and the cursing that followed.

The $900 million opening will feature a half-hour holomusical that will block out a quarter of the sky and be visible to beach-goers from north of Los Angeles to the Baja. The ribbon cutting will also mark the end of Prasad's duties, and the start, she hopes, of a long vacation.

"Forget about the travelers and dignitaries," she says. "I'll be the one catching the first flight out of here."

POWERED BY HYDROGEN SLUSH TRANSPORTED THROUGH SEAFLOOR PIPES, A CATAPULT ACCELERATES CLIPPERS TO 400 KNOTS IN 13 SECONDS—BUT PASSENGERS EXPERIENCE LESS THAN A 1-G LOAD. THE 4.25-KILOMETER RUNWAY ENSURES THAT AIRCRAFT HAVE ROOM TO RECOVER WHEN TAKEOFFS ARE ABORTED.

[5]

RIDE OF THE CENTURY?

"We've made hypersonics hip again!" AirTransWest president Davie Mack shouted to the crowd celebrating the Mach 10.02 (10,862 kph) speed record set by an ATW Global Clipper on a flight between Sydney and Seattle last summer. The first scheduled passenger flight to exceed Mach 10, the crossing did not improve on the previous record transit time of 1 hour, 48 minutes. The three firms in the Clipper-manufacturing consortium FAASTA—Fuji Heavy Industries of Japan, Alenia of Italy, and AeroSpace Technologies of Australia—threw the party last month at Oregon's Museum of Hypersonic Flight in Portland.

"Here at Portland's great museum, we are surrounded by the craft that blazed our trail, but nobody can blaze like we can!" Mack crowed. Thousands of FAASTA and subcontractor employees were joined by the Clipper's four ATW crew members as well as all 50 passengers who were aboard the flight.

Last year FAASTA and ATW announced the promotion to celebrate the bicentennial of flight and the airline's fifth anniversary of Clipper operations: On one of the airline's trans-Pacific flights, pilots would receive permission to override the Mach-liner's neural system—a network of sensors and actuators with control laws synchronizing the propulsion system with shape-morphing action—which selects the most efficient cruise speed under the design limit of Mach 10. On that flight, promoters announced, the aircraft would accelerate past the Mach 10 limit. Passengers who happened to be on the flight would win a trip from any of the coastal intercontinental airports in ATW's service area. According to ATW spokesbots, the promotion increased ATW's ridership by eight percent. The company repeatedly acknowledged the contribution to its success made by United Hydrogen Processing Energy Reserve, U-HyPER.

Although the evening's speakers referred to the flight as "historic," Clipper passengers were unanimous: No big deal, but the free flight and hyper-gala were okay with them.

Guests partied among promotional displays and museum exhibits tracing the achievements that led to the Mach-liner's development, beginning with the world's first Mach 10 flight, which took place 99 years ago. On a vintage flat-panel display, a continuous video loop showed a tiny research craft called the X-43 on a December 2004 flight in which it pioneered supersonic combustion with a primitive scramjet engine. Shimmering paintings of today's Clipper bore an uncanny resemblance to displayed prints marked "future hypersonic vehicles," the work of Dennis Petley, an engineer who studied hypersonics at a Virginia research center early in the last century.

One of FAASTA's displays, a cutaway scale model of a Clipper, presented a tutorial on the Mach-liner's rocket-based, combined-cycle propulsion system, the components glowing sequentially as a recorded voice called out the speed increments. On runways not equipped with a catapult launch system, the Clippers use a liquid-air cycle ejector aerospike rocket engine to take off and accelerate to Mach 1.5, at which speed the turboramjets take over. The transition from the turbine to the dual-mode ramjet occurs in the Mach 4 to 4.5 range, and the handoff to the scramjet occurs at about Mach 6. The scramjet then accelerates to the cruise speed of Mach 10. Each time the display's voice called "Mach 10," a small plastic flask of champagne tumbled from a dispenser inside the model scramjet's air intake into a silver tub of ice, and the voice started the speed cycle again.

All of FAASTA's 41 subcontractors were included in the guest list. CompoCo, supplier of the nanotube-based Epoxyplasm™ used in sculpting the Clipper's carrier fuselage, brought several samples of the material, programmed to morph from one geometric shape to another: sphere to cube to triangle and back. Epoxyplasm™ provides thermal protection and enables the vehicle to reduce its wing sweep from 74 degrees at takeoff to 55 degrees at high-Mach flight.

Industry observers note that the real reason for ATW's celebratory mood is that even though business travelers still prefer the telepresence offered by Virtual Reality provider Opticon, vacation travel is back.

THE CLIPPER'S SINGLE ENGINE INLET USES A VARIABLE-GEOMETRY, INTERNAL-FLOW DIVERTER TO DUCT AIR THROUGH TURBINES OR RAM/SCRAM ENGINES. THE LINEAR AEROSPIKE ROCKET PROVIDES TAKEOFF THRUST.

FROM A MENU THAT ALSO INCLUDES SEVERAL WORK AND PLAY OPTIONS, PASSENGERS CAN SELECT A RANGE OF OUTSIDE VIEWS, TRANSMITTED BY PHOTO-OPTIC FLAKES BAKED INTO THE EPOXYPLASM™ SKIN.

GLOBAL CLIPPER

LENGTH: 62.4 METERS

TAKEOFF SPAN: 51.8 METERS

HIGH MACH SPAN: 33.7 METERS

TAKEOFF WEIGHT: 368 TONS

First Look:

Solo's 2104 Skypod LS

The Solo Industries consortium has slapped a lid on price increases with an attractive 20-year lease program and a medium-price model ($739,995) that targets median-income families who want a utility flier that will hold its value.

Total thrust is up two percent over 2103, while a redesign of the interior helps hold the price line. Solo vice president of marketing Marvin S. Aung said that information feedback from current owners' aura readings indicated that less than a fifth of the market will miss the holographic entertainment center, for example, as average trip times recorded at the company's headquarters are only 23.071 minutes.

"By mining the data from universal fleet telemetry, we're better able to match what buyers are thinking while we tap into the performance data," Aung said. "With each flier sending us 40 gigs of data every second from thousands of sensors, we have some pretty good numbers to work with." The onboard monitoring system that alerts both factory and passengers to any system degradation has proven to be as valuable a tool to marketers as it is to Solo's quality and safety ensurance divisions. Solo's central data storage facility maintains a log of roughly 700 trillion terabytes, Aung said. The company reports only five instances worldwide during 2103 in which its fliers' parachute recovery system deployed, and only one flier was written off as unrecoverable; it sank in deep water.

Morphing composites provide both lift management and directional control with a ride that's comfortable even in gusty air. The Solo Silence™ active noise-cancelling system does its usual

The Specs: Skypod LS

PRICE AS TESTED: $751,310 (INCLUDES DESTINATION CHARGES); EMPTY WEIGHT: 420 KG (W/O POWER CELLS); PAYLOAD: 445 KG; SEATING: 4 + 1; LEASE PAYMENT (BASE PRICE): $4,958/MONTH, 20 YEARS.

MINIMUM SPAN: 4.75 METERS; MORPHED SPAN: 7.35 METERS; MAXIMUM EXTERNAL NOISE LEVEL/HOVER: 77 DB(H); COEFFICIENT OF DRAG AT CRUISE: 0.21; PROPULSOR: WESTINGHOUSE 614T; SEA LEVEL POWER: 1,603 KW (2,150 SHP).

MAXIMUM SPEED: 770 KM PER HOUR; STOPPING DISTANCE (MAXIMUM EFFORT): 225 METERS; MAXIMUM ALTITUDE: 5,300 METERS; MAXIMUM G LOAD: 7.3; MAXIMUM ENDURANCE: 105 MINUTES (5-MINUTE RESERVE).

AVAILABILITY: MID-APRIL 2104 (NORTH AMERICA); LEASE TERMS: 6.5%, 20 YEARS WITH $75,000 DUE AT SIGNING; TAX, BEACON CODE EXTRA. ALL SOLO VEHICLES ARE THE PROPERTY OF SOLO INDUSTRIES AND ARE NOT AVAILABLE FOR SALE.

excellent job of reducing external acoustic footprint. Wind noise, apparently due to a leaking seal, was the only intrusive internal annoyance on the demonstration flier, and it became very irritating at speeds above 250 knots. (We turned up the sound system and ignored it.)

For 2104, Solo brought back one nostalgic touch: the cup holder, reminiscent of an accessory from the surface-rider minivans of 100 years ago. With beverages now carried in garments, one wonders how people will use these.

Improved lift management for the new model reduces the response time to gusts so well that you hear the turbulence more than you feel it. Microsurfaces that form part of the composite matrix are extended electrostatically to manage smaller bursts of energy, while the morphing lift surfaces abeam the keel plate twitter so constantly and rapidly as they adjust to smooth the ride that they seem to have a bad case of coffee nerves. Those who prefer to ride the bumps can turn off the system to provide that sport-flier feel.

Exterior and interior "millions of colors" options create shades to match your mood and surroundings, and we can only wish the code controlling windshield tint were as responsive. Testers were unanimous in pronouncing the glass as too dark under almost all outside light conditions.

Still, Solo has gotten a lot right for a flier in this price range. Not the fastest flier out there and with an interior that seems to have been designed to please tastes that run American bland, this is one flier that probably won't turn many heads. But it's aimed at the broadest segment of the market, and the LS should find itself many a nest in diverse clusters of thinly populated communities as the nation disperses farther from urban centers.

SOLO'S SKYPOD: AIMED SQUARELY AT THE MARKET MEDIANS IN TERMS OF DESIGN, PERFORMANCE, PRICE, AND SIZE, THE LS FOR '04 COMBINES EMINENTLY FORGETTABLE STYLING WITH A PACKAGE OF ACCEPTABLE ATTRIBUTES THAT MEET THE NEEDS OF BUYERS IN THE EVER-EXPANDING METRO-RURALS (ABOVE).

THE BIG EYE GOES LIVE

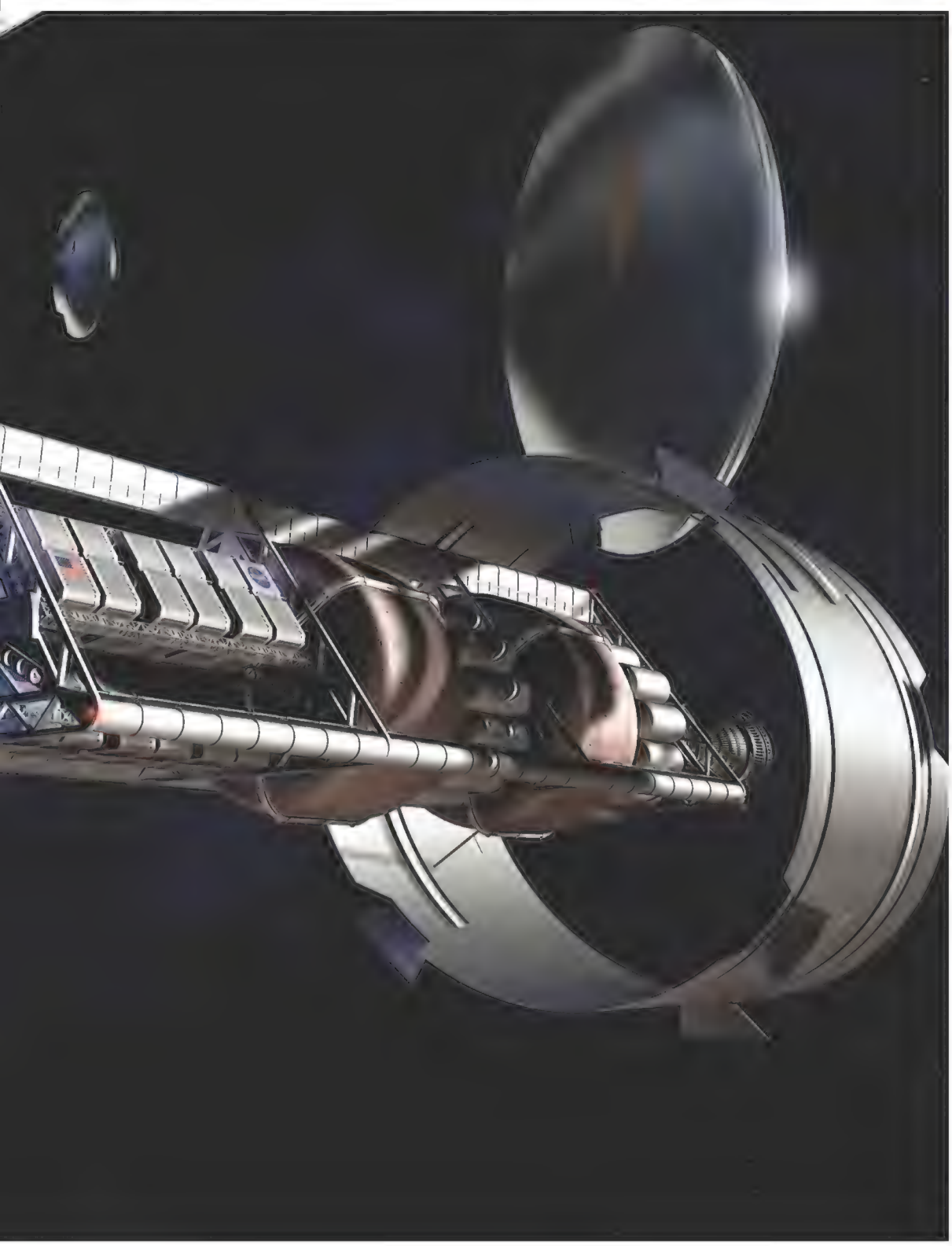
>>Fonda Nuñez never gets tired of the view from L2, no matter how tedious the journey or mundane the cargo. "These month-long 'halo runs' [round trips to the halo orbit around Libration Point 2] can get dull, I admit," she says. "But when you're out there working a million miles from home, and suddenly you catch that little blue ball out of the corner of your eye and think about where you are, it reminds you why you got on this ride."

Nuñez should have no trouble getting excited about piloting next February's 04-D30 mission on the space carrier *Shepard*. If the schedule holds, she and her crew of five will install the last of more than 100 free-flying elements in the Big Eye telescope, which may finally answer one of humanity's oldest questions: Are we alone?

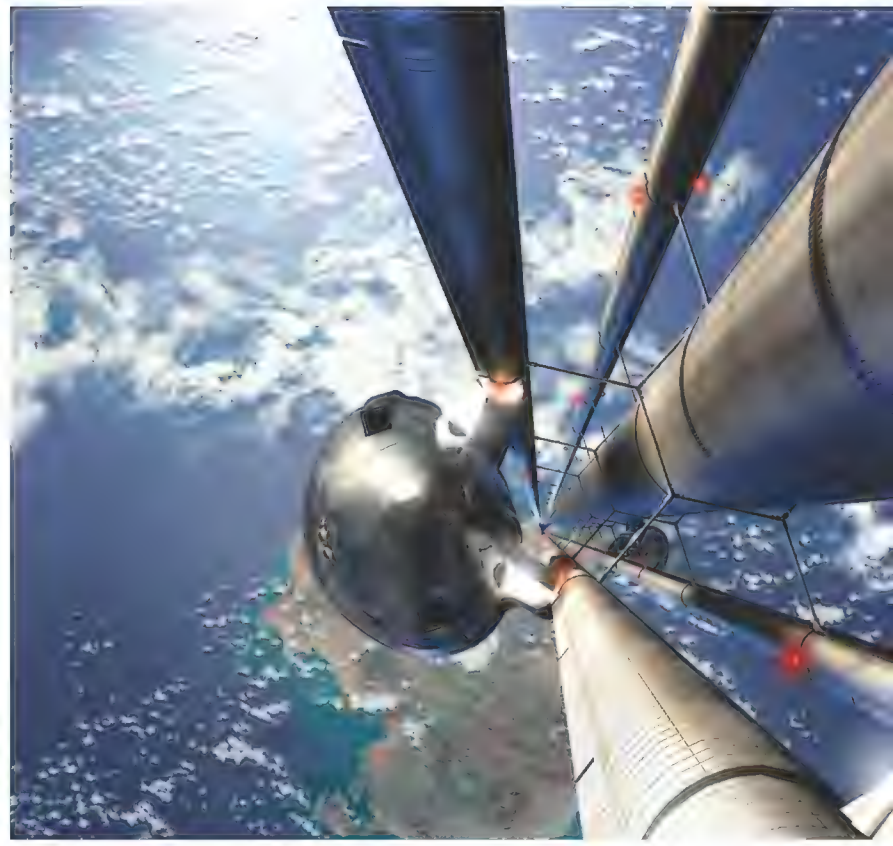
Americans on the project were hoping to finish the Big Eye in time for the bicentennial of flight, but they couldn't quite make the deadline. Begun by the United Nations Academy of Astronomy in 2096, the huge interferometer should have enough resolving power to make out continents, perhaps even large cities, on a planet 19 light-years away, the distance to the suspected civilization in the Eta Cassiopeiae star system.

For nearly a century, planners of large space telescopes have considered L2 prime real estate. There, the gravitational tugs of Earth and the sun are in balance, so a spacecraft in a tight "halo" orbit around L2 doesn't get pulled toward either one. And telescope detectors stay well chilled, which makes L2 the perfect site to take advantage of Big Eye's exquisite sensitivity.

But Miranda Dylan, head of astro-engineering at the academy, admits the team was chagrined to find that precise positioning of the telescope's electronically controlled, gossamer-thin elements turned out to be so time-consuming. "It was something we thought we had figured out back in the 2020s," she says.



NUCLEAR CARRIER *SHEPARD* WILL INSTALL THE FINAL MIRROR OF THE "BIG EYE" INTERFEROMETER (ARRAY NOT SHOWN TO SCALE) EARLY NEXT YEAR. *SHEPARD* IS SHOWN DOCKED TO THE L2 STATION, WITH ITS FERRY VEHICLE AT ONE END AND ITS RING-LIKE HEAT RADIATOR AT THE OTHER.



LADDER CLIMBER'S VIEW: PASSENGERS ON THE SPACE ELEVATOR LOOK DOWN ON ANCHOR ISLAND, OFF THE EQUATORIAL WEST COAST OF AFRICA, ON THEIR WAY UP TO GEOSTATIONARY ORBIT.

Scientific and political controversies also plague the Big Eye. Are the Eta Cass signals even real? First heard in 2045 by the venerable Allen Telescope Array on Earth, they have been tracked steadily by the Lunar Farside Array (Elfa) ever since. Some astronomers still maintain it's a natural signal from an unknown type of bursting star. "That's very much a minority opinion," maintains Science Secretary Miles Kerry. But the naysayers' arguments have been bolstered by the so-far-total lack of success in deciphering the meaning of the broadcasts—if that is indeed what they are. Elfa is only a few months from completing the arduous task of beaming up to the residents of Eta Cass the Earth's Encyclopedia Humana, a digitized record of human history, despite protests from the Montana-based Ludd League and others.

Scientists hope the Big Eye will settle the controversy once and for all by returning visual evidence of a civilization on Eta Cass. This is just the kind of boost the

flagging space program needs right now, says Busei Singh, professor emeritus of space policy at Delhi University in India. "The recent report by the *Tsiolkovsky* Accident Investigation Board (TAIB) nailed the problem right on the head," he says. "There is no long-term vision for space."

Singh believes that budget restrictions make it unlikely we will return to the golden era of the 2060s, when astronauts roamed Mars in a search (futile, as it turned out) for signs of life. Nor has the private space sector been especially lively lately. The lunar Selene Corporation has had trouble making ends meet since the 2080s, when helium mining interests abandoned the moon in exasperation over stagnant growth in the fusion energy market. (A recent report by the U.S. Physics Council estimated that affordable home reactors are still 30 years away.) That left the Chinese government—which is still negotiating with several other governments, including the United States, to build and operate a lunar maximum-security prison—and the Amazonian Biotechnology Company (ABC) as Selene's only large customers.

In 2051, the latter became the first private venture to sign a long-term lunar lease in order to conduct experiments considered too risky for even the most secure bio-containment facility on Earth. And waste disposal continues to be profitable. But, predicts Singh, "toxic dumping will never be that big of a market."

The healthiest segment in the space arena remains tourism. After an 18-month work stoppage, the Ladder (officially, but only rarely, referred to as the Artsutanov Space Elevator) re-opened for business in May. In a special Bicentennial promotion, North African Space Associates (NASA), the Ladder's operator, will slash rates by 50 percent for trips to both the geostationary and lunar transfer levels, and is offering deep discounts at its orbital hotel.

The Lunar Worker Lottery, instituted by ABC in 2090, also has been an unqualified success, generating some 65 billion Euros to date. Even though Opticon's virtual lunar simulator is reported by many off-Earth veterans to be absolutely faithful to the visual experience of exploring the moon, there is still no good way to simulate the exhilarating 20-foot leaps that are possible in lunar gravity. So far 12 people have won the annual first prize, a two-week working vacation at ABC's lunar lab/containment facility.

Still, insta-polls taken by State Focus Groups say the public, with the exception of well-heeled "Ladder Climbers" who can afford the 90,000-Euro elevator ride, is no longer terribly excited about space exploration.

That could change soon, says Singh, especially if Big Eye turns up evidence that the signals from Eta Cass are more than just cosmic noise.

LUNAR WASTE DISPOSAL IS STILL PROFITABLE FOR THE CHINESE GOVERNMENT, BUT FOR HOW LONG? HERE A ROBOTIC MOON WALKER DISPATCHED FROM THE NEAR-SIDE BASE PREPARES TO DEEP-SIX A BIOHAZARD CONTAINER UNDER LUNAR SOIL.


WARNING
RESTRICTED AREA
BIOHAZARD
CAUTION
RADIATION
HAZARD

THROUGH DARKEST IRAQ WITH GUN & COBRA

TAKING IT ONE DAY AT A TIME WITH A MARINE AH-1 PILOT.

STORY AND PHOTOGRAPHS BY JAMES COX

DAILY JOURNAL: During the war with Iraq, I kept an informal journal of my experiences for my family. Sometimes I didn't write for days, either because of the tempo of operations, or because of the sheer boredom. Some of the events that I wrote about rated one or two words—enough to jog my memory later. Others took a paragraph to capture. My method was haphazard: As I had thoughts, I wrote them down. The recollections are based solely on my perspective. My point of view was that of a U.S. Marine, assigned to serve as a helicopter squadron operations officer, flight leader, and AH-1W SuperCobra pilot. The following account is based on that journal.

On March 18, 2003, two days prior to the U.S. invasion of Iraq, my unit—Marine Light Attack Helicopter Squadron 269, which consisted of 18 AH-1W SuperCobras (we call them Snakes), nine UH-1N Hueys, and 323 Marines out of Jacksonville, North Carolina—moved about half of our aircraft into Kuwait from the USS *Saipan*, an amphibious assault ship that was our home at sea. I was designated the division leader for a four-Snake flight that was tasked with destroying three Iraqi border posts. We moved ashore so we could react more quickly to the rapidly changing and confusing timeline for the coming battle's opening phases.

CH-46Es glow in a view through night-vision goggles aboard the flight deck of the USS Saipan.

I had never been so nervous as I was flying off the boat that day. This was my first combat mission, and as we flew across the teal waters of the Persian Gulf toward Kuwait, I thought about my children. I feared them being left fatherless, and I begged God for strength.

For two days at a clandestine airfield inside Kuwait, we went through the details of our mission, studied target photos, and rehearsed. My copilot, Kujo, sat on his cot for hours on end with his eyes closed, pantomiming the hand and finger movements he would

use to fire the Cobra's missiles. Even the lightest breeze stirred up a lot of powdery sand in this arid area, and in winds of 10 knots or more, visibility was quickly down to almost nothing.

On the morning of March 20, 2003, rumors circulated that the Coalition had begun combat operations with missile strikes. It all seemed dream-like, but reality hit as I was walking to my tent. There was a loud roar from the sky, and I looked up. The noise got louder, and I saw a missile flash past the camp—a Chinese-made Iraqi Seersucker heading toward Kuwait City. The air raid sirens began to growl, and we spent the whole day running back and forth between the tents and our bunkers while wearing chemical suits and gas masks. The tension was draining me, and I still had a mission to fly.

The missile scare added to the confusion of sporadic communication and conflicting information. We'd been planning all along to launch the attack at night, when the Iraqis couldn't see us. But maintenance crews needed time to prepare the aircraft, and ordnance needed to be loaded. We sat in a tent with a radio close by and our Cobras only about 100 yards away. No less than five times we got an order—"GO RIGHT NOW!"—only to have it canceled. On a couple of occasions, we started out to the aircraft with our gear, and once we even strapped in

AH-1Ws, with 20-mm cannon and missile racks, prepare to depart for forward bases in Kuwait.

This was dark. Seat-cushion-clenched-in-your-butt dark. The desert was devoid of detail, and I had no depth perception. We couldn't see obstacles until we were right on top of them. We hadn't even met the enemy yet, and the mission was already nerve-wracking.

Red tiedowns prevent the helos' rotor blades from windmilling in stiff sea breezes.

and started to crank engines. My stomach was tied in knots all day long, but around dinnertime we finally got the word to launch, and this time it stuck.

The winds had been picking up all day, and visibility was down to less than a half-mile. My flight was supposed to lead the others out of the airfield, but in the confusion, another flight departed ahead of us. Panicky radio calls were made so that we wouldn't have a midair collision. At some point, we flipped down our night-vision goggles. The NVGs amplify even extremely low ambient light, but with reduced visibility and no moon, it was the darkest night I'd ever flown in.

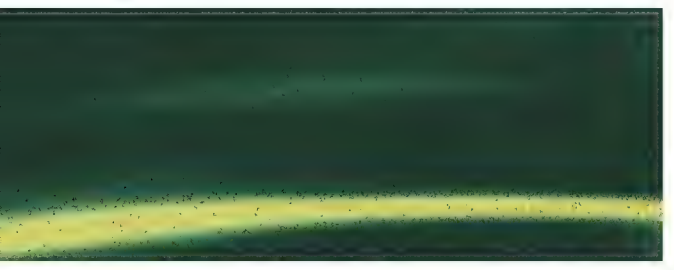
I'd been a Marine for almost 15 years. I'd been flying Cobras since 1990, and I had over 2,500 flight hours and over 600 NVG hours. But this was dark. Seat-cushion-clenched-in-your-butt dark. The desert was devoid of detail, and I had no depth perception. Imagine scuba diving in a pool of mud—no sense of up or down or of motion relative to anything. Visibility was about a quarter of a mile, and we couldn't see obstacles until we were right on top of them. I just missed a 100-foot radio

AH-1W rear cockpit instrument displays tell the pilot he's at 80 knots and 200 feet above sea level.

tower. I could feel the panic welling in my throat as my inner ear seemed to tumble with vertigo. Eventually we slowed to about 50 mph, just groping along, like driving a car in thick fog. We hadn't even met the enemy and the mission was already nerve-wracking.

Flying north along Highway 80, our flight reached the grid coordinates marking the point where we would split up. The first two Snakes, with me in the lead, turned east to a position where we would fire our first rounds. The second section headed west. At the Iraq border, Kujo began to work the forward-looking infrared (FLIR) sensor to locate the target. It seemed like it was taking him forever. Looking down to ensure that no one was trying to sneak up under us to shoot us down, I saw a Kuwaiti family outside their farmhouse, looking up and watching the war unfold around them.

Kujo finally located the border post. Three missiles away. Border post destroyed. *Thank God that's over.*



After struggling through the pitch black back to our base in Kuwait, a flight that should have taken 10 minutes but lasted more like 45, we finally landed. As I climbed out of the cockpit, my legs were shaking—not exactly a sign of manly courage. I thought I was the only one experiencing such intense fear until I spoke to the other pilots. To a man, each was ghost white. Finally drained of adrenaline, we made our way back to the tents.

But we didn't sleep a wink the whole night. Every time we'd lie down, the air raid siren would start howling again, and we'd trudge back to the bunkers. Just after first light, we launched from Kuwait to head back to the *Saipan*. I was punchy from lack of sleep. Safely aboard, I stumbled across the flight deck and down to the ready room. As I set my gear down in one of the chairs, the Marine Aircraft Group commander walked up to me and gave me a comforting pat. I felt the tears well in my eyes. He told me how proud he was of all of us. With a huge lump in my throat, all I could manage to say was "Skipper, it was so goddamned dark out there." I thought that if the rest of the war was going to be like that first night, I wouldn't survive.

A lone UH-1N flies a training mission in the Kuwaiti desert, where the terrain mimics Iraq's.

Early in the afternoon of March 24, my two-Snake section launched from the ship and proceeded to the Iraq city of Nasiriyah. Marine ground units had entered the city days earlier and seen the bloodiest action of the war so far. This was my first daytime flight. Night flying in the desert was difficult, but daylight left us feeling naked and exposed. We made our way around the edge of the city, and I radioed a Marine ground unit on the city's north side. As we approached, we were directed to engage an enemy mortar position along a riverbank. We rolled in to attack with rockets and guns, and Kujo slewed the cannon, strafing up and down a trench. I fired rockets, which cracked with loud explosions. While we were orbiting over friendly units, Kujo had spotted Iraqi artillery to the west. We got clearance from the forward air controller and began firing missiles.

On one of the holding orbits, I noticed two burned-out hulks. I'd heard that the Marines had lost two armored personnel carriers in an ambush the day before, and some men had died. We raced back for fuel and ammunition, then returned to join up with the Marines as they starting moving north.

My section scoured the fields, ditches, and small enclaves beside the road as we escorted the convoy. A few kilometers to the north, I spotted some Iraqi soldiers waiting in ambush in an irrigation ditch. Hidden in the trench and undetected by the convoy, they

On their flights into the Kuwaiti desert, Marines overflew dozens of Coalition encampments (above). Right: Fully armed and fueled Snakes prepare to launch while desert winds whip up a haze of fine sand.

began to move toward the road. I called the FAC and he cleared me to engage. The Iraqis were now within 50 meters of the convoy. From 500 feet, I lowered the nose, and with my left hand reached down to the weapon switches and selected the cannon to shoot fixed forward. Looking through the glowing symbols of the transparent head-up display, I lined the gun pipper up on the Iraqi closest to me. In that split second, I realized that until this moment I had destroyed *things*—buildings, vehicles, weapons—but I hadn't shot at a *man*.

A million thoughts raced through my mind. Guilt. Fear. Sorrow. And, finally, anger that these men were trying to kill my brother Marines. I pulled the trigger.

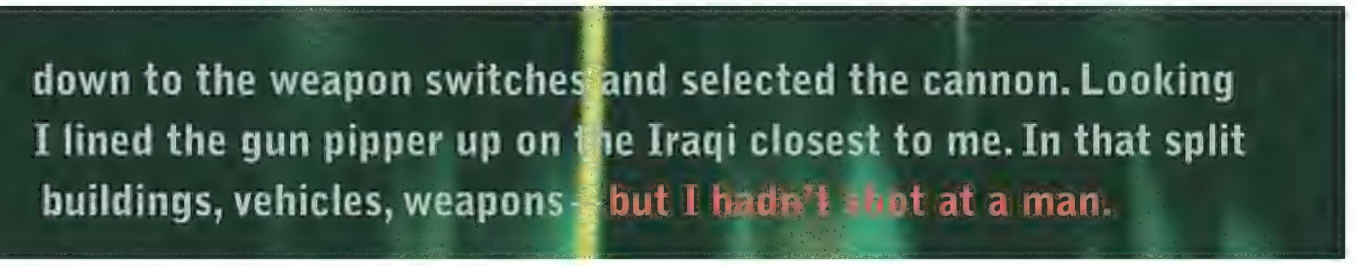
After a refuel and reload, we set out after sunset to where the Marine unit had stopped for the night. Like the pioneers with their covered wagons in the old west, the Marines had their tanks and armored vehicles in a tightly coiled formation, with each vehicle assigned a sector of fire. As we approached, I could see that they were engaged in a firefight, with fire spewing out in every direction: TOW (tube-launched, optically tracked, wire-guided) missiles, 25-millimeter chain gun, M-1 tank main gun, and heavy machine gun fire. Orbiting at 150 feet, we were so low that the machine gun rounds made our teeth rattle. Every couple of minutes, the FAC gave me a rollout heading, and I'd either ripple a pod of rockets or blast away with the cannon. Every clearance added the words "danger close"—meaning that the fire is close to friendlies. It was chaos.

A British GR1 Tornado jet checked in with the FAC to work with us. The FAC was having trouble talking the jet's crew onto the target. Finally the FAC identified the target by using a large fire as a reference, and the Tornado began its target run. As the jet passed over the city of Nasiriyah, all hell broke loose. Large-caliber anti-aircraft artillery (triple-A) and SAMs (surface-to-air missiles) streaked through the sky in every direction. The 100-millimeter triple-A rounds arced up and exploded, looking as though they were moving in slow motion.

From 500 feet, I lowered the nose, and with my left hand reached through the glowing symbols of the transparent head-up display, second, I realized that until this moment I had destroyed things—

This was the first time we'd been shot at, and it was absolutely terrifying. I nearly froze at the controls. I thought I'd known fear before, but I've never been as scared as I was that night, and the sensation was more intense

The Kuwait City skyline offers unique landmarks (right). Atop the Snake's engine enclosure is an infrared missile jammer (orange).



Glowing symbols light a head-up display (above). The round screen warns of hostile radar signals.

than any I'd ever felt before. Evading the gunfire, we flew back to the rear area for more fuel and ammunition. We flew one more sortie, which was just as chaotic and violent as the previous mission. After flying for nearly 14 hours straight, we headed back to Jalibah to spend the night.

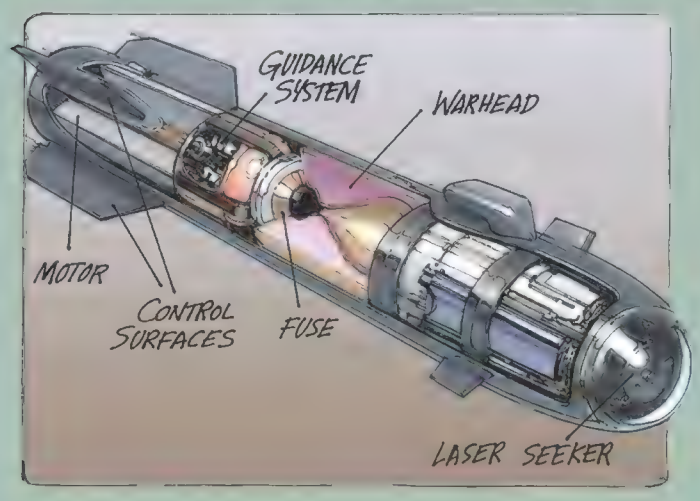
We then endured a period of three days of sandstorms that grounded us. After it cleared, we were tasked with supporting the British forces around Basrah, in southern Iraq. We began screening the north of the city for possible Iraqi ambushes, staying well clear of the built-up areas. We began to scour the outskirts of Basrah with our sensors when Kujo observed Iraqi military equipment in bunkers in the desert outside of the town. We had just begun to size up the weapons cache when Kujo noticed an anti-aircraft gun with a large pile of ammunition at the ready. Standing off from the target, we engaged it with a TOW missile. Rolling off target, we saw Russian-made T-62 heavy tanks hidden in larger bunkers. Kujo began to engage the tanks with Hellfire guided missiles. When each tank was hit, debris would spray off the hull, followed by a long shower of flames and sparks as secondary explosions from the tank's ammunition cooked off.

Launching again that evening in support of the Brits, we were sent to attack a suspected covert meeting site that the Fedayeen forces had been using. Making our way over oil fires the Iraqis had set to blind our aircraft, we began to take heavy small arms fire. Muzzle flashes winked on the ground, and tracers zipped by us in the night sky. The volume of fire forced us to turn around and go back to the west side of the city. Knowing that we would not be able to get to the Fedayeen site, we moved to engage our second target: Ba'ath party headquarters. Finding the target on the FLIR, Kujo began to pump Hellfire missiles into the three buildings. My wingman began to shoot at the target with TOW missiles at maximum range. The missiles seemed to float toward the target, their tails aglow. At the end of that long mission in Basrah, we landed in Jalibah—our new home for the remainder of the war.

Two days later, we were back supporting the U.S. Marines as they moved up the highways between Nasiriyah and Al Kut. We launched in the early afternoon to head up north, and when we reached the front lines, we saw that the FAC we were supporting had his unit stopped along a road. On arrival, we were asked to check out a village a short distance in front of the Marines. We flew north along a highway with no apparent threat in sight. But as we moved around the western side of the towns, large black smudges started appearing around our aircraft. After a pregnant pause, loud booms shook the aircraft. Someone in the village was firing large-caliber triple-A at us. With shouts of "Break left, break left!" on the radio, our flight turned hard and raced back toward the friendlies. Kujo, ever the wizard, lased the triple-A battery and got a grid location from the computer. After we passed the coordinates to the FAC, Marine artillery took out the triple-A site.

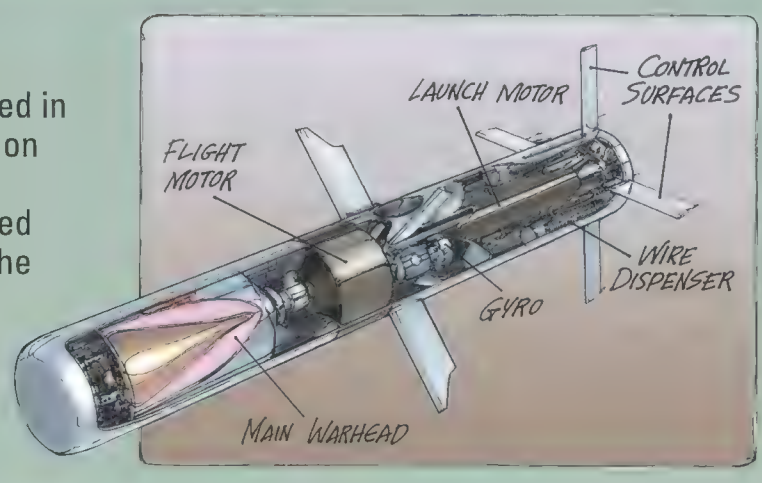
On April 5, 2003, as Coalition forces approached Baghdad, the tension grew. Not knowing what the Iraqis had waiting for us made us fearful. During a night mission along the road that led from Al Kut to Baghdad, I ended up on the radio with Sideshow, a FAC for one of the Marine ground units and one of my closest friends. Sideshow's units were approaching Salman Pak, a large village along the Tigris River and about 15 miles from the capital. The previous night, a Marine Cobra from California had apparently hit a

Hellfire and TOW missiles



Hellfire: developed in the 1970s as an air-to-ground, anti-armor missile for the U.S. Army and Marine Corps; homes on reflected light from a laser illuminator; successor to the TOW, it offers greater stand-off distance from targets.

TOW: tube-launched, optically tracked,wire-guided missile. Developed in the late 1960s; mounted on trucks and helicopters; steering signals conveyed via thin wire that trails the missile like thread coming off the end of a spool; flare in tail helps make missile visible.



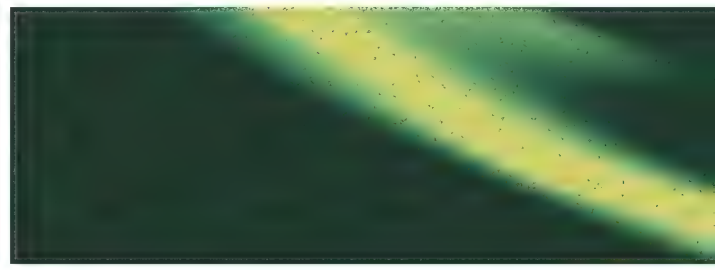
HARRY WHITVER (2)

large set of power lines and crashed in this area. Around Baghdad, the power lines were about 350 feet high. The wires and stanchions were a tan color—difficult to see during the day and next to impossible at night.

Tasked with conducting a reconnaissance of Salman Pak to determine the enemy's disposition, I led the flight over and around the town. Wally, my wingman, reported seeing a military compound in the center of the town. Kujo used the FLIR to search for weapons, and within moments he had located an Iraqi SAM battery. After coordinating with the FAC, I maneuvered the flight to the west and rolled my aircraft in toward the target. As Kujo was lining up a missile shot, I noticed two flashes from my right side. Glancing toward them, I saw two heat-seeking missiles corkscrewing rapidly and coming right at us. Yanking the aircraft left into a violent nose-down maneuver and ejecting decoy flares, we headed for the ground to break the lock of the missiles' heat seekers. We started at 800 feet, and when we'd gotten down to around 100 feet, I pulled up. By the time we'd bottomed out of the dive, we had descended all the way down to 50 feet and had broken lock with the missiles. When we looked up, we found ourselves in the maze of high-voltage electrical lines. It was as if someone had dumped a plate of spaghetti on our heads.

The event seemed to last for an eternity, but in reality the whole engagement was over in about four or five seconds. The missiles traveled at about Mach 2.5, so there was not a lot of time to react—and definitely not enough time to be scared. I ran into Sideshow up in Tikrit days later, and he told me the missiles had missed me by about 50 feet.

By mid-April, the end of the war nearing, I launched with two Snakes and a Huey in what we called a hunter-killer team. Our mission was to support the Marine forces that were closing in on Tikrit, Saddam Hussein's hometown. As we approached, the radio said the Marines were taking artillery fire. With plenty of gas remaining, my flight began to conduct a reconnaissance to the southeast in hopes of finding the Iraqi artillery. Fly-



Forward arming and refueling points were positioned in remote areas throughout Iraq. Here, a hunter-killer team—Huey and Snake—are refueled and re-armed "hot," with engines running and rotors turning. The device extending upward from the Huey's windshield cuts high-tension wires to prevent entanglement with the rotor blades.

ing over a grove of date trees at dusk, we found it: heavy artillery and a rocket launcher. Shortly after sunset, we were given approval to attack. After we flew multiple passes at the target, the artillery and rockets were destroyed and what was left was burning.

After refueling and re-arming, we set out to the west of Tikrit, where one of our pilots, Howdy, had begun to attack a bunker complex. The complex took up about 1,000 acres, and included large warehouses and bunkers with ammunition used by what remained of Hus-

Squadron personnel encircle an AH-1W prior to their first strikes. The author is atop the wing.

Explosions ripping out of the complex were boiling 6,000 feet into the air. The night sky was as bright as day, and I could see without my NVGs. As explosions slashed from bunker to bunker, the fire grew until a mushroom cloud formed.

sein's forces. Requesting as many jets as he could get, Howdy began to direct laser-guided bombs onto the various targets. Keeping clear of the area, I positioned my flight to the north of the complex and began to hammer missiles into the bunkers. Explosions ripping out of the complex were boiling 6,000 feet into the air. The night sky was bright as day, and I could see without my NVGs. As explosions slashed from bunker to bunker, the fire grew until a mushroom cloud formed.

Howdy was approaching minimum fuel, so he handed FAC duties off to me. Using our laser to illuminate targets for laser-guided bombs and missiles, I began to direct the jets into the target area. The inferno continued to grow. Although I've seen lots of Hollywood movies where the explosions and special effects were awe-inspiring, I never thought a real fire could be this extreme.

After a quick trip to refuel and rearm, we returned to the complex and I resumed directing the jets. As I hovered the aircraft, Kujo pumped more missiles into the remaining bunkers. In a Cobra next to me, Wally was engaging bunkers with his missiles. Friar was orbiting behind us in the Huey to provide security. After we had lased targets for approximately 25 bombs and missiles, Friar reported that we were taking fire; an Iraqi artillery unit had zeroed in on us. As we moved to escape, another Iraqi unit began to shoot missiles at us. The enlisted crew chiefs in Friar's Huey returned fire with their door guns. As we pulled out of the area, geysers of fire were still erupting from the bunkers. We turned south, toward our base. I was ready to go home.

A UH-1N Huey's door-mounted 7.62-mm M240 machine gun frames a hunter-killer SuperCobra.

As I reflect on the month that I spent in Iraq, I'm amazed at what we accomplished. On a personal level, I'm astonished to be alive. This was my baptism of fire, and given some of the extreme flying conditions that we had to endure, my survival made me appreciate life more. It's obvious to me now that I lived through some miracles—and that at times my fate rested in the hands of a higher power.

On a different level, I'm overwhelmed at what my squadron achieved. Although the vast majority of people in the squadron had no combat experience, the pilots and enlisted aircrew flew 2,023 combat sorties. And the maintainers kept us in the air, repairing combat damage to our aircraft that they had never seen in peacetime.

We did not lose a single Marine to an accident or to the Iraqis. I survived and my unit survived, and the individual men and women in the squadron performed heroically.

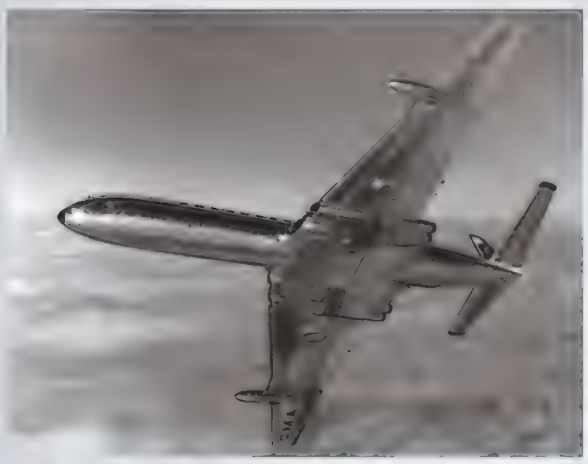
I'm also astounded at the intensity with which the Marine Corps fought. Assigned to defeat experienced Republican Army and Republican Guard units, the Marines showed a tenacity that made it possible for U.S. Army units to move into Baghdad within days of the initiation of hostilities.

For almost 15 years, I had trained to perfect my trade, and this was the ultimate test.

Resto

Celestial Body | D.H. 106 Comet 4C

When Robert Hood looked at the de Havilland D.H.106 Comet fuselage sticking halfway out of a hole cut in the huge hangar at the Museum of Flight's restoration facility in Everett, Washington, he was reminded, oddly, of a vegetable. "[Restoring] this airplane is like peeling an onion," says Hood, the museum's former Comet restoration project manager. "After stripping off a layer of corrosion you find another one." Hood and current manager James Goodall, who took over after Hood's wife pointed out that Robert was supposed to be retired, for Pete's sake, led a team of some 10 volunteers, from former Coast Guardsmen to senior Boeing veterans, in a quest to make the airplane, itself retired for more than 30 years, a museum star.



DE HAVILLAND ARCHIVES

De Havilland's Comet had a promising future but a disastrous career. In 1952 the D.H.106 Comet 1 became the first commercial jetliner, flying the London-Johannesburg run for British Overseas Airline Corporation. Within a year, two Comets crashed on takeoff in India and Rome. In January 1954, the Comet with the registration GALYP, or Yoke Peter—BOAC's trailblazer—exploded over the Mediterranean, and in April, another Comet disintegrated off the coast of Sicily. The British government grounded the fleet and launched an intensive investigation. After scraping the sea's bottom for debris and reconstructing what was left of Yoke Peter, investigators needed only four months to figure out what had happened. The Comet, like other pressurized aircraft, has pressurization and depressurization cycles—the fuselage expands at altitude and contracts during descent. The flexion had caused the aluminum skin to fatigue, or weaken, and a crack developed in the skin abutting a square-cornered navigation window atop the fuselage. In the final cycle, when the fuselage expanded at altitude under pressurization, the crack gave way, causing catastrophic structural failure—the airliner disintegrated. Later versions, like the one being restored by the Museum of Flight, a Mark 4C built in 1959, incorporated the solution: hatches and windows with rounded corners. But in the interim, Boeing came out with the 707 and Douglas with the DC-8. Britain had lost the lead in jet transportation.

The de Havilland design had life in it yet; the company built some 100 D.H.106s. Mexicana Airlines bought the museum's Mark 4C—serial number 6424—brand-new in 1960 and flew it for 10 years between Mexico City, Chicago, Paris, and points in between, then took it out of service. The old jetliner has since led a rough life. One buyer repainted it in BOAC livery and tried to sell it as a cargoliner. (When the restoration is complete, Mexicana colors will replace the BOAC paint scheme.)

Abandoned at Seattle's Paine Field in 1979, 6424 was used over the years by the local fire department to practice dousing jetliners. It had small leaks

PHIL SCHOFIELD

The world's first jetliner (above), BOAC's de Havilland Comet made its first passenger run, London to Johannesburg, in May 1952. A dozen or so are now undergoing restoration, including a 1959 4C at Seattle's Museum of Flight facility in Everett (right), where project managers Bob Hood (at left) and Jim Goodall have their hands full—at the moment, with cockpit electrical assemblies.

around the door and above the cockpit, and the cockpit instruments had gotten soaked. When the restorers removed the floor, they found four inches of water corroding the aluminum.

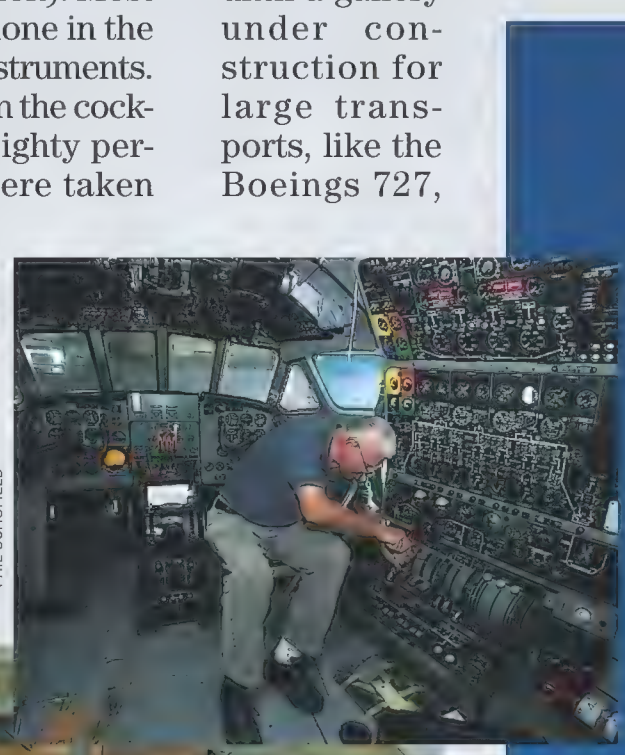
"When I first saw it, I thought, *uh-oh*," says Goodall, who has restored everything from a Curtiss Robin to an SR-71. Hood, Goodall, and crew stripped the Comet's interior, the galleys, and the cargo-bay liner, and scraped the exterior down to bare skin (except for the tail and aft fuselage, which were left poking from the restoration hangar; the team left the BOAC paint on to protect the Comet from corrosion). Most of the intensive work was done in the cockpit, especially on the instruments. "We've got 4,000 man-hours in the cockpit alone," says Goodall. Eighty percent of the instruments were taken apart, treated for corrosion, reassembled, and repainted. A former Comet flight engineer said many of them didn't look that good back when they were in service. "We've still got placards to install, wire bundles to do," Goodall says.

"Our senior materials guy for three years did nothing but inventory parts, and there's over 100,000 parts," says Hood. "We probably have the largest collection of Comet parts in the world." When the crew completes the job, it plans to offer what's left to crews restoring Comets in England.

The Seattle museum doesn't currently have the space to exhibit the finished Comet, but rather than park it outside, where the ever-present Northwest moisture might undo all the anticorrosion labor, the Comet's caretakers will leave it in the restoration facility until a gallery under construction for large transports, like the Boeings 727, 737, and 747, is finished. Goodall estimates that 6424 will be in a proper exhibit in about four years. Until then, the Museum of Flight allows visitors into the cockpit.

—Phil Scott

The team took the cockpit back to the bones (below left). One of the biggest challenges was finding replacement windows. Jerry Bowen helps finish up the the flight engineer's panel (below center), while Hood and Mike Savoy (in cherry picker) remove the rudder.



PHIL SCHOFIELD

JAMES C. GOODALL (2)

HOW SCIENTISTS DECIDED WHERE TO LAND ON MARS.

NEXT STOP:

BY MICHAEL MILSTEIN

A simulated Mars Exploration Rover roams a simulated planet. In January it all becomes real.

GUSEV CRATER

If planetary scientists could do whatever they wished, they'd probably send a spacecraft to land on the floor of Valles Marineris, a gaping canyon that stretches 2,500 miles across the Martian surface, exposing the planet's past in pancake-like layers of rock. But the twin NASA spacecraft due to land on Mars in January won't be going there.

Researchers might be just as happy to have robots roam Gale Crater, a saucer-like depression near the equator of Mars that may once have held a body of water shaped like Oregon's Crater Lake. But the landers, with wheeled rovers larger and more capable than Mars Pathfinder's Sojourner robot, which roamed the planet in 1997, won't be going to Gale either.

Hundreds of scientists and engineers spent close to three years sifting through more than 150 destinations for the Mars Exploration Rovers (MER) before they settled, with a sigh of relief, on two: another lake-like crater called Gusev, named for 19th century Russian astronomer Matwei Gusev, and a mineral-rich plain called Meridiani Planum. Never before had scientists looking for places to land on the Red Planet had so many options. Never had they known so much about each candidate site ahead of time. And never had the stakes for getting there seemed quite so high.

Unlike Pathfinder, the $800 million MER is not a demonstration of new technology. This time the spacecraft's job is to return information, particularly clues about whether life once existed on Mars. Researchers scrutinizing the planet's surface for landing zones had to weigh the scientific interest of the site against the odds that winds, rocks, or some other hazard would knock the craft out of commission. Two-thirds of all past attempts to reach Mars—including NASA's 1992 Mars Observer, the 1998 Mars Climate Orbiter, and the 1999 Mars Polar Lander—have crashed or otherwise failed, and MER project managers are only too aware that another spacecraft loss could jeopardize NASA's plans for Mars exploration.

"You always have to take some risk, but you want to be sure you take it in a calculated manner," says geologist Matt Golombek of NASA's Jet Propulsion Laboratory in Pasadena, California, who co-chaired the committee that selected the landing sites. "It doesn't matter how important the science payoff is—if you don't land safely, you don't get anything."

So in September 2000 the committee began laying the groundwork for an exhaustive series of reviews to choose destinations for the rovers, which will explore out to a radius of about three-quarters of a mile from their landing sites. "Everyone just wanted to tear into everything, pick everything apart," says Golombek. Even though many researchers who joined the discussion originally championed other sites, almost everyone agreed in the end that Gusev and Meridiani are, on balance, the two best places to land. That doesn't mean they are the most interesting scientifically, or that they pose the lowest risk to MER's cocoon-like airbags, which will bounce as many as a dozen times to cushion the shock of landing. But in the calculus of risk and reward, they emerged the winners.

Scientists did not have the whole of Mars to choose from. The need for solar power to keep the rover instruments running during the 90-day science mission limited the options to a narrow band around the planet's equator, covering just 10 percent of the surface. Farther north or south, the sun would be too dim, and the instruments could be crippled by night temperatures dipping below –200 degrees Fahrenheit.

High elevations were out. Otherwise the descent through the wispy carbon dioxide atmosphere would be too brief to allow the parachute to pop out, the airbags to inflate, and the retro-rockets to fire before the craft hit the ground. The terrain also had to be fairly flat. Slopes steeper than two degrees over about half a mile, or more than 15 degrees over about 30 feet, could send the airbag-enveloped landers rolling out of control.

Despite these constraints, MER had a huge advantage over past Mars landers. Two spacecraft currently in Martian orbit—the 1996 Mars Global Surveyor and 2001 Mars Odyssey—had photographed potential landing zones in unprecedented detail. Mission designers had millions of close-up snapshots to work with, compared to fewer than 8,000 less-detailed pictures taken by NASA's Mariner orbiters prior to Viking, the first successful Mars

LEFT: NASA/JPL; ABOVE: NASA

landings in 1976. Looking back on that mission, Tim Parker, a JPL planetary geologist who took a leading role in the MER site selection, says, "There was so much we didn't know, there were probably some definite luck factors" in Viking's success.

Even with Pathfinder, "the ignorance we had was probably rather blissful," Parker says. Since then, closer looks at the planet have revealed that the landing zone has potentially dangerous gullies and hillocks that mission planners didn't know about at the time.

While having more information made picking the MER landing sites easier, it didn't always seem that way to the scientists. The two spacecraft, named *Spirit* and *Opportunity*, are the most advanced robots ever sent to Mars. Not only are their instruments better—the cameras sharper, the spectrometers for determining rock chemistry and mineralogy more discriminating—but their aiming will be more precise thanks to upgraded navigation software and other improvements since 1997. Pathfinder needed a landing zone so big—about 60 by 150 miles—that there were only a few places flat and smooth enough to touch down. But the MER landers can home in on a target area about a quarter that size.

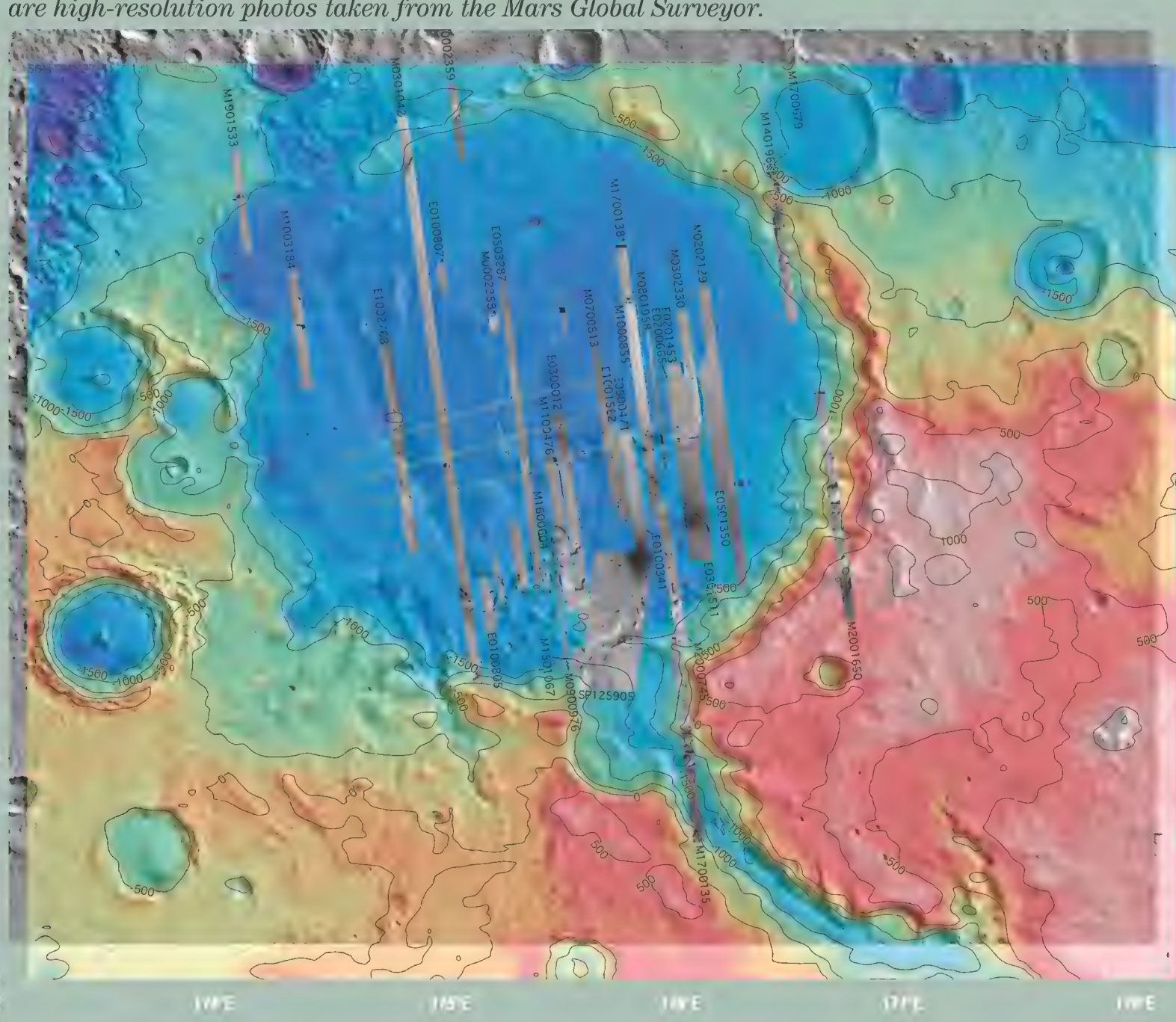
When Parker sat down at his high-powered computer to study digital maps of the surface, he kept finding more places where he could fit a stretched-out ellipse outlining the minimum runway MER needs to land.

He managed to identify about 155 candidate ellipses in all sorts of terrain. A couple of the potential sites—Melas Chasma and Eos Chasma—were within Valles Marineris, the largest canyon in the solar system. Another fell near Apollinaris Patera, a volcano that shows signs of having once sent water gushing to the surface. Still another covered what looks like a vast system of river channels called Athabasca Vallis, just downstream from where a major flood appears to have raged.

With 155 possibilities, it became much tougher to decide where to land, especially when scientists could study each one in more detail than ever before. Public meetings started two years before launch so that scientists could argue for their favorite sites; this added another layer of outside review and countered the criticism that NASA liked to make closed decisions.

"Not only did we have more data than any other landing site selection process, but we also had more people, more eyes, more minds thinking about

Gusev Crater as mapped by spacecraft altimetry from Mars orbit (low areas appear blue, high areas red). MER's planned landing ellipse is at center. The long black-and-white strips are high-resolution photos taken from the Mars Global Surveyor.



this than ever before," says John Grant, a geologist at the Smithsonian's National Air and Space Museum who co-chaired the landing site committee. "It meant there were no surprises."

It also was no surprise that some of the favorites reflected individuals' own research interests. Some scientists pushed for sites that would help them understand the magnetic orientation of Mars. Others wanted to know about ice near the poles. Most, though, agreed that the search for life should drive the mission. They ranked the top sites based on whether they might turn up evidence of water—a basic ingredient of life—and whether any signs of past biological activity might remain.

Superimposed on this scientific priority list were other concerns, mostly having to do with safety—how many hazardous rocks littered the landing zone, what was the likelihood of dust clouding the rover's cameras or blanketing the solar arrays. Even the local scenery was considered—disguised, in unemotional science-speak, as "public engagement" and "site aesthetics" that would appeal to taxpayers. Once these factors were added, the 155 candidates dwindled to fewer than 10.

On occasion, amiable tug-of-wars broke out, with engineers preferring to avoid risk and scientists pulling for a site full of intriguing mesas and ravines. "Sometimes you could tell from [the engineers'] body language," recalls project scientist Joy Crisp. "It said 'No, I don't want to go there.' That made the rest of us nervous."

More often, though, "it was the scientists saying 'We want to go there' and the engineers saying 'Let's see if we can,' " recalls JPL's Mark Adler, the mission's lead engineer. Meridiani Planum, for example, captivated scientists because it holds a big outcropping of hematite, a mineral that typically forms in the presence of water. But its elevation was a bit too high. Engineers solved that by upgrading the MER navigation system so the spacecraft could better measure the distance to the ground, and adding rockets to compensate for unpredictable winds. That provided a large enough safety margin to make Meridiani a go.

NASA GLENN RESEARCH CENTER

Tests at a NASA facility in Ohio proved MER's airbags tough enough for Mars rocks.

To better simulate landing conditions at the top candidate sites, mission planners hired a landscape architect to lay out a Martian scene, created with rocks selected from the California desert. Trucks hauled the rocks to Sandusky, Ohio, where crews bolted them to a platform inside the world's largest vacuum chamber, at NASA's Glenn Research Center. With air sucked out of the chamber to simulate the thin Martian atmosphere, the crews dropped a dummy spacecraft onto the platform to see how it handled different slopes and rock configurations. A bungee cord attached to the model yanked it down at the speed the 1,200-pound landers will hit the surface of Mars.

Meanwhile, like a swarm of paparazzi, the craft now orbiting Mars photographed each of the frontrunner zones, so the top few sites are probably now the most studied places on the planet. Researchers looked at infrared images to determine how quickly regions cooled after the Martian sunset. Since big rocks retain heat, the images gave hints about the number of boulders lying about. The scientists had the orbiters fire radar waves at the surface to make sure it was solid enough to support the rovers. Such reconnaissance showed that Athabasca Vallis contained a jumble of ragged rocks, rather like Devil's Golf Course in Death Valley. Even the maneuverable rovers could get stuck there, so it was out. Steepness ruled out Gale Crater—the landing ellipse was too big to avoid the walls.

By January of last year the choice had come down to four, two of which would be relegated to backup status. One of the finalists was a broad Martian channel called Isidis Planitia, where scientists hoped to find a variety of rocks washed down from the highlands. Isidis lost some of its appeal when a closer look suggested the rocks might be buried instead of exposed. Researchers likewise lost interest in Elysium Planitia, which was plenty safe but wasn't especially intriguing geologically. When scientists at the final committee meeting last January broke into groups to consider the pros and cons of each site, the two most popular spots lured about 50 people each. Isidis drew two and Elysium a lonely one. ("The only reason it had one person was because we assigned him to it," says Grant. "And he didn't want to be there.") In April, based on the scientists' recommendation, NASA gave the final nod to Gusev and Meridiani.

That doesn't mean all doubts have been quelled. The biggest unknown still facing MER is the Martian wind. It was wind, in fact, that ruled out landings in the canyons of Valles Marineris, which may act as a wind tunnel, whipping up gusts of 80 mph. Even though JPL's supercomputers have spent months trying to forecast a few days' worth of weather, the Martian winds remain largely unpredictable.

So when the landers arrive at their destination in January, JPL engineers and the scientists who rely on them will be sweating every last foot of the descent. All the careful targeting, all the workshops and agonizing over where to touch down, could be thrown off by a gust blasting the landers sideways. But if they land safely, it will take just one small discovery—perhaps a photo of water ripples in Gusev's dried-up lakebed, or confirmation of hematite and other water-formed minerals at Meridiani—to make scientists glad they took the trouble.

SIGHTINGS

Maybe it was the weather: four long, perfect mid-July days of it. Maybe it was the location: Orville and Wilbur's hometown. Maybe it was the fact that all three North American military jet teams performed, that more than 150 types of aircraft were on display, that you could buy a ride on a Ford Tri-motor, a Douglas DC-3, or a Bell UH-1 Huey. Something about the 2003 Dayton Air Show, held last July 17 to 20, made it stand out from the year's other celebrations of the centennial of flight. It was, as one performer said, "the airshow of the century."

Those who didn't make it to the party can get a sense

of the jubilation from Tyson Rininger's photographs. Rininger, who drove to Dayton from his studio in Monterey, California, used a 400-mm telephoto lens, which, he says, combined with a teleconverter and the magnification factor of his digital equipment, produces shots that look like they were taken from a chase plane, though all were made from the ground.

Rininger's postcards from Dayton, left to right: Manfred Radius, famous among airshow fans for the graceful routine he flies in his GmbH glider, gave a stunning performance against a clear blue sky. The Canadian Forces Snowbirds, in a formation so close they look like an M.C. Escher pattern, entranced the crowd with nine-abreast maneuvers and a unique style. The Snowbirds, flying Canadair CT-114 Tutor jet aircraft, seemed to be everywhere in the sky at once. A meticulously restored Blériot XI (top), the type in which inventor Louis Blériot made the first crossing by airplane of the English Channel in 1909, was brought to Dayton all the way from Sweden by owner and pilot Mikael Karlsson.

Maybe the crowd was what made the Dayton show extraordinary: An estimated 180,000 fans turned out over the four days, strolling among the big airplanes on static display—from left, a Boeing C-17, Lockheed C-130 and C-141 (light gray), and Rockwell B-1—cheering the performers, and loving the weather.

Aero Aesthetic

Aerospace Design: Aircraft, Spacecraft, and the Art of Modern Flight

ed. by Anthony M. Springer. Merrell, 2003. 192 pp., $49.95.

PEGGY HOPKINS

Mach 20 sculpture? Wind tunnel models for Space Transportation System concept vehicles, including an early version of the eventual space shuttle (top row in gold).

The companion to an exhibition of NASA artifacts and images appearing now through February 4, 2004 at the Art Institute of Chicago, *Aerospace Design* is a collection of essays that asks "Why do aircraft look the way they do?" The book opens by asserting that "aerospace design is more than a matter of nuts, bolts and rivets," but struggles to substantiate the claim that design is an artistic process.

Its authors—mostly academicians—approach the issue as historians and art critics. National Air and Space Museum curator Dominick Pisano's history of streamlining exposes the influence of aircraft on the industrial design of everything from cars to pencil sharpeners. James Hansen, an Auburn University historian and *Air & Space/Smithsonian* contributor, follows with a fascinating history of wind tunnels, but makes a weak case for them as objects of beauty.

Further along, NASM curator John D. Anderson ponders whether aerospace designers intentionally sculpt aircraft to be beautiful or leave form to follow function. In searching for an answer, Anderson cites the writings of novelist and engineer Nevil Shute ("a beautiful aircraft is the expression of the genius of a great engineer who is also a great artist") and aviation historian Richard Smith ("instead of a palette of colors, the aeronautical engineer has his own artist's palette of options"). Anderson presents two case studies, the SR-71 and the DC-3; in each case, aesthetics resulted from aerodynamics and engineering factors such as center of gravity, streamlining, engine power, and performance.

Some of the last chapters, like NASA Centennial of Flight director Anthony Springer's short but interesting discussion about the tools of the trade, deal with today's changing design environment. Long-retired slide rules are thanked for their service, and new technology—such as computer-aided design, computational fluid dynamics, and 3-D simulations—is mentioned, but its influence on aerospace design isn't critically assessed. Nor do we see how designers actually design. We're introduced to Richard Whitcomb, the brilliant inventor of winglets, the supercritical wing, and the area rule, which gave the F-102 its wasp waist, but there is no analysis of how his ideas were conceived and developed. It's like praising Picasso for being a genius without any consideration of his technique, biography, or sources of inspiration.

Aerospace Design's 220 images, most in color, are mainly from NASA's collection, and are interesting but dully reproduced. The strongest images are the least familiar: the gargantuan wind tunnels that dwarf the featureless aircraft models in them and the intimate pictures of engineers and test pilots at work.

Unfortunately, *Aerospace Design* is not greater than the sum of its parts. It looks at aviation design for an aesthetic dimension that doesn't exist, except as an accidental by-product. This doesn't mean that the book is not fascinating—just misdirected; it is well-written, beautifully illustrated, and pregnant with historical detail. Even if *Aerospace Design* fails to meet its objective, the book illuminates the logic behind design and the accidental beauty design creates.

—Matthew Stibbe is a freelance business and aviation writer living in London.

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From the Flight Deck: An Anthology of the Best Writing on Carrier Warfare

ed. by Peter B. Mersky. Brassey's, 2003. 341 pp., $29.95.

"If there were a who-is-the-best-pilot-in-the-squadron contest, I think that I would win," backhandedly boasts U.S. A-6 pilot Frank Elkins when it becomes clear to him that his antics have too easily convinced other pilots of his prowess in the left seat. Writing before his life ended in an October 1966 crash in Vietnam, Elkins goes on in disgust about life aboard the USS *Oriskany*—the never-ending sweating in the heat belowdecks, having to count "one hundred deep breaths in one position and one hundred deep breaths in another position" to fall asleep—and about not making the most of his experiences—backing down from fights, "loafing at football practice, loafing on the farm sometimes."

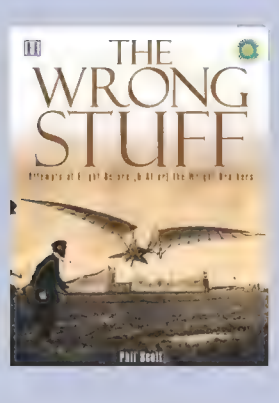
Though *From the Flight Deck* is no stronghold of machismo—there is much self-doubt, fright, and insecurity—Elkins' memoirs and letters to his wife Marilyn, excerpted from his posthumous *The Heart of a Man*, display a level of vulnerability not found among the accounts, interviews, and fiction that fall before and after.

With George van Deurs' history of Eugene Ely's near-disastrous 1910 first flight from a ship, followed by descriptions of World War I attacks on a Zeppelin, the battle of Midway from the Japanese point of view, and a British helicopter pilot's engagement of Iraqi patrol boats, editor Peter Mersky has collected the requisite material about milestones and conflict. It's his inclusion of more unexpected matters, such as the chaos of a deck fire during Vietnam, experiments to evaluate rubber carrier decks, conversations with the skipper of the USS *John F. Kennedy*, and a female anti-submarine pilot's very masculine thoughts on practiced landings, among the nearly 30 other entries, that helps

The Wrong Stuff? Attempts at Flight Before (and After) the Wright Brothers

by Phil Scott. Hylas, 2003. 224 pp., $24.95.

The Swan That Grew Into an Ugly Duckling. The Flying Ginsu Knife. These are two of the wry nicknames frequent *Air & Space/Smithsonian* contributor Phil Scott has given to inventions like Alexander Graham Bell's Cygnet and Northrop's XP-79—not-so-grand ideas that never took off, or didn't go very far if they did. Beginning with Leonardo da Vinci's Great Bird, *The Wrong Stuff?* combines sepia-tone illustrations and photographs of aviation's less successful projects with accounts of their airworthiness, including statistics. Biographical blurbs often prove that mastery of one discipline doesn't translate to genius in aircraft design. Hiram Maxim, whose steam-powered kite barely leapt from the ground on its lone takeoff attempt, invented a machine gun to make war more humane. "He was as successful at that as he was at building airplanes," Scott quips.

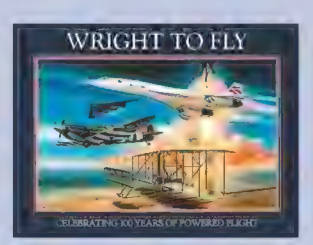


—Melissa DeSica

Wright to Fly: Celebrating 100 Years of Powered Flight

by Peter R. March. Trafalgar Square Books, 2003. 216 pp., $60.

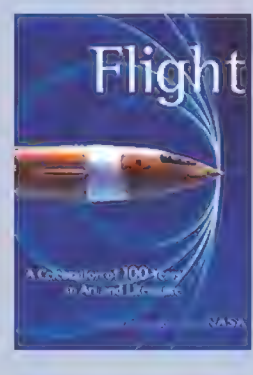
Using 100 paintings—including 12 commissioned for the book—and well-researched text, *Wright to Fly* catalogs the aviation age, beginning in 1903 with the Wrights' first powered flight. Each year is summed up with a two-page spread; one page has a month-by-month chronology of the year's aviation feats and a commentary, the other has a full-page painting. Though Peter March's text is terse and slightly breathless, the book is redeemed by its art, which includes glorious iconic images such as a DC-3 over 1930s New York City, Britain's Avro Lancaster bomber climbing away from a World War II "dambusters" mission, and Yuri Gagarin's *Vostok 1* reflecting Earth below.



—Matthew Stibbe

Flight: A Celebration of 100 Years in Art and Literature

ed. by Anne Collins Goodyear, Roger Launius, Anthony Springer, and Bertram Ulrich. Welcome Books, 2003. 240 pp., $39.95.



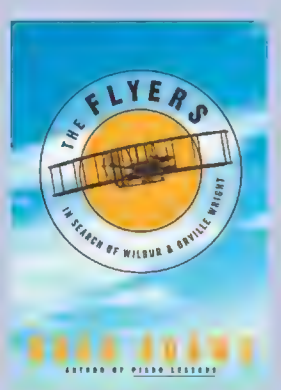
"How can they know that joy to be alive/Who have not flown?" B.P. Young's poem "Flight" is just one of the many works in this imaginative celebration of flight's first century. Among the aerospace-theme photography, paintings, sculpture, and mixed media by artists as diverse as Andy Warhol, Charles Schulz, Robert McCall, and Georgia O'Keeffe are entries by the equally disparate assemblage of Norman Mailer, Jimmy Doolittle, John Kennedy, and Joni Mitchell. Memoirs by Earhart, Yeager, and the Lindberghs recount some of flight's groundbreaking moments, and in the letters of astronaut Frank Culbertson—aboard the International Space Station on September 11, 2001—some of its saddest.

—Kelli B. Grant

The Flyers: In Search of Wilbur & Orville Wright

by Noah Adams, Crown Publishers, 2003. 212 pp., $22.

National Public Radio correspondent Noah Adams' intimate portrait of the Wright brothers delights from the first line as it explores the family dynamics that produced such mild-mannered yet determined individuals. Adams weaves recollections of small-town inhabitants with the Wrights' technical notes and family correspondence and visits the sites of some their most famous flights—glider test flights on North Carolina's Outer Banks, innovation at Ohio's Huffman Prairie, and exhibitions in France—so that he can better imagine the inadequate runways and describe the sensations of cold, gut-wrenching air currents and the soft new sound of an airplane propeller.



—Nan Chase

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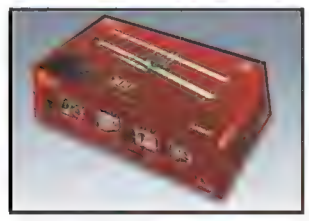

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instill an appreciation of the scope of carrier life.

For each excerpt, Mersky introduces the author and his or her circumstances. He has artfully excerpted the selections from their original text, though he sometimes leaves too little context for readers unfamiliar with Navy jargon and squadron procedures. Bracketed explanations could have helped clarify passages like Harrier pilot Sharkey Ward's description of a Falklands sortie—"I was able to get airborne with the AWI, Morts, for our first CAP mission together." (Translation: Ward and his air warfare instructor, named Morts, were on their first combat air patrol.)

Lively fiction, with excerpts from James Michener's *The Bridges at Toko-Ri*, Richard Newhafer's *The Last Tallyho*, and Richard Sale's "Battle Descending" from *Teenage Aviation Stories* (with bailed-out Brewster Buffalo pilot Brad saved from a Focke-Wulf at the last moment by his wingman, Stinky), helps to break up the monotony of memoirs. These stories, with actions shaped by dramatic force rather than radar blips or remaining pounds of fuel, seem to fly by too quickly; one or two more would have enriched the collection.

As with most writing about carrier warfare, Mersky's selections focus on Western and World War II powers. It would have been nice to see Spain, India, or even Russia dashed into the mix. Nonetheless, *From the Flight Deck* is never dull or repetitive and is a solid choice for an all-around sampler of life in a naval air wing at sea.
—Sam Goldberg is an associate editor at Air & Space/Smithsonian.

Flyboys

by James Bradley. Little, Brown & Company, 2003. 398 pp., $25.95.

More about war than aviation, *Flyboys* is the graphic story of eight U.S. pilots, gunners, and navigators who in the final months of World War II bailed out in separate incidents over the island

100 YEARS OF FLIGHT FOR KIDS

First Flight: The Story of the Wright Brothers

by Caryn Jenner. DK Publishing, 2003. 48 pp., $3.99.

With large print wound around many colorful illustrations and photographs, this elementary school reader is more engaging than most books on the Wright brothers meant for grown-ups. Included with the usual information are delicious details that will humanize the Wrights to young readers: Wilbur decided not to go to college after having his teeth—and self-confidence—knocked out in a hockey game; Orville traded popcorn for a friend's share of their boyhood printing company; and neither brother thought the automobile would catch on.
—Sam Goldberg

The Wright Bat

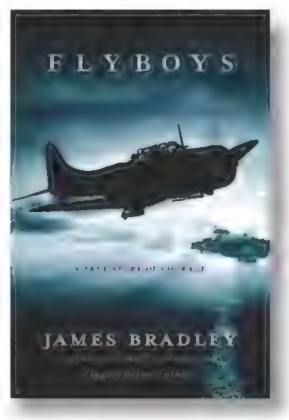
Available from www.midwestproducts.com or (800) 348-3497. Ages 8 and up, $6.49.

5:40 p.m.: Read box. Learn that the "Wright Bat," a rubber-band-powered helicopter, was Wilbur and Orville's favorite toy, given to them by their father in 1878, and that the boys "played with it until they wore it out."

5:43 p.m.: Begin assembly. Instructions straightforward.
5:58 p.m.: Prepare for first launch attempt. Eight-year-old wearies of winding propeller with finger 50 times, hands to sister. Ten-year-old gets to 48, accidentally lets go. Bat sputters to ground. Plastic unharmed.
6:01 p.m.: Father winds to 50.
6:02 p.m.: First launch attempt. Bat twirls upward 15 to 20 feet, floats back down. Pronounced "cool."
6:06 p.m.: Rewind. Second launch attempt. Bat lodges in tree.
6:10 p.m.: Frisbee fails to dislodge Bat.
6:13 p.m.: Frisbee stuck in tree.
6:15 p.m.: Eight-year-old goes to garage to search for basketball.
6:18 p.m.: Basketball brings Frisbee and Bat down. Ten-year-old: "Let's get it stuck again!"
—Tony Reichhardt

of Chichi Jima. The Japanese killed some, and let the others perish under horrible conditions involving starvation, torture, and cannibalism. Small wonder the mens' families were told neither about the shocking human behavior that caused their loved ones' deaths nor about the secret war crimes tribunal held after V.J. Day to try their captors.

Flyboys also tells the story of a ninth pilot, rescued after bailing out many miles away, who has no connection to the rest of the story. His experience feels artificially grafted on. He was George Bush, then the nation's youngest naval aviator and later its 41st president.



In his earlier *Flags of Our Fathers*, James Bradley did a superb job describing war by focusing on the battle for Iwo Jima, where his father was one of the men in Joe Rosenthal's famous flag-raising photo. *Flags* never struck a false note. *Flyboys* is different. The text is riddled with stylistic quirks that seem to have been created to help brand this very commercial product. For example, everyone who flew, no matter what his crew position, is a Flyboy, capitalized throughout. The B-25 Mitchell medium bomber somehow becomes a Billy, a term no one ever used.

The stories of all nine fliers are compelling. Whether he is describing the firebombing of Tokyo or the mistreatment of the eight airmen, Bradley dwells on the worst in the human spirit, that which creates carnage and suffering. The author often wants to do too much, such as tracing the development of modern Japanese militarism and the history of air power. Some readers may have difficulty with a view of war that places Japanese atrocities in Nanking on a par with the bombing of Hiroshima.

Bradley interviewed U.S. and Japanese veterans for the book, and we are repeatedly told that he is disclosing events previously held secret, but there is little here that has not been told before. Even when the text grabs us, holds us, and makes us want to read more—and it does throughout, because the story is interesting and the author's writing is lean and pointed—we never get away from the feeling that something is unnatural about the narrative, that every sentence was composed with an eye toward the media blitz to come at publication.

—Robert F. Dorr is the author of 60 aviation books.

TRY IT YOURSELF

First Flight: The Wright Experience Flight Simulator

by Bihrle. Available from www.mywrightexperience.com, $49.95.

First Flight claims to be the most accurate simulation of flying the Wrights' original 1903 *Flyer*, as well as the 1902 glider and their 1911 Model B. Certainly the *Flyer* was almost untamable, and it's no different here. The airplane is unstable and its controls are unresponsive—if this is the real Wright experience, then Orville, Wilbur, and the two pilots who used this sim to train for a flight on a *Flyer* reproduction this December were skilled indeed. With the more forgiving Model B, it's possible to take simulated trips around College Park, Maryland, where the Wrights instructed military pilots. *First Flight* is a well-executed simulation—its graphics are realistic, detailed, and smooth-flowing—but Microsoft's *Flight Simulator 2004*, at only five dollars more, has an easier-to-fly Wright *Flyer* and a lot more besides.

—Matthew Stibbe

CREDITS

The Invasion of Manchester. Marshall Lumsden is a retired magazine editor who lives in warm and sunny Malibu, California. For a history of the 315th Fighter Squadron, visit *www.324thfighter.com.*

Chasing the JB-2. Dave Winn is a retired U.S. Air Force brigadier general.

God Save the Vulcan! Craig Mellow is a freelance journalist based in London.

"It's All About Fire, Smoke, and Noise." Preston Lerner last wrote for *Air & Space/Smithsonian* about the Hughes Racer replica (Apr./May 2003).

Air & Space/Smithsonian | December 2103. Editors Sam Goldberg, George Larson, Linda Shiner, and Tony Reichhardt imagined what they'd be writing about if they were still around for the December 2103 issue of *Air & Space.* They're now collaborating on the invention of a time machine so they can check their work. NASA engineer Dennis Petley, who contributed ideas to the design of the Global Clipper, will be their first passenger.

Paul DiMare is a freelance illustrator. "Although the subject matter is daunting, and every little detail had to be designed from scratch, it's great fun to visualize a future that may be," he says.

Through Darkest Iraq With Gun and Cobra. James Cox, an attack helicopter pilot and major in the U.S. Marine Corps, is currently assigned to the Second Marine Aircraft Wing at Marine Corps Air Station Cherry Point, North Carolina. His article reflects his own experiences and views and does not necessarily represent the views of the Department of Defense or the U.S. Marine Corps.

Restoration: Celestial Body. Phil Scott thinks all airliners are dangerous and prefers piloting a Cessna Skyhawk around the airport in Lincoln Park, New Jersey.

Next Stop: Gusev Crater. Michael Milstein is an environmental and science writer at *The Oregonian* in Portland, Oregon.

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Not every issue of the magazine is available. For a list of editions that are out of print, check the Web at the above address.

Smithsonian
National Air and Space Museum

— General John R. Dailey, USMC (Ret.), and his wife Mimi
In front of the Museum's Boeing F4B-4. Dailey's father and his inspiration, USMC Brig. Gen. Frank Dailey, flew the very plane that's now in the Museum's collection.

PHOTO: CARLYN RUSSO

"I want to give visitors access to the entire Museum collection...."

"I hope to inspire future generations by making the legacy of the Wright brothers accessible to them. The thousands of artifacts at both the flagship building on the National Mall and the new Udvar-Hazy Center show the history, science, and technology of flight in dynamic, meaningful ways." —General John R. Dailey

To celebrate the Centennial of Flight, the National Air and Space Museum is opening its companion facility, the Steven F. Udvar-Hazy Center, on December 15, 2003. For museum director John R. "Jack" Dailey, the opening of this facility will be the culmination of a dream and of many years of effort.

Dailey, a highly decorated pilot and a leader in the Marine Corps, at NASA, and now at the National Air and Space Museum, is leading the expansion of the most visited museum in the world. To commemorate the opening of the Udvar-Hazy Center and the Centennial of Flight, Dailey and his wife Mimi have made the National Air and Space Museum a beneficiary of their will, making them members of the *Smithsonian Legacy Society.*

Find out how you can include the National Air and Space Museum in your estate plans. Fill out and return the reply form below, call 202-633-2602, or e-mail legacy@nasm.si.edu.

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A&S 01-04

Air & Space/Smithsonian magazine is now available on audio tape for members who cannot read standard print due to disability. For the basic membership fee, you will receive a print copy of the magazine plus the audio version. If you or someone you know has been struggling with the standard print version because of vision loss or other disabilities, contact the Smithsonian Accessibility Programat 1-888-783-0001 and receive your next issue of Air & Space on tape.

CALENDAR

December 1–30
"Pan Am and the Golden Age of Air Travel." This art exhibit focuses on Pan Am's Clipper period, from 1935 through 1946, when it became the first American airline to fly to foreign destinations. Highlights include vintage route maps, advertisements, postcards, brochures, and a pilot's jacket. Museum of American Financial History, New York, NY, *www.financialhistory.org*, (212) 908-4695.

December 6
Holiday Concert by the Air Force Band of Flight. United States Air Force Museum, Wright-Patterson Air Force Base, OH, (937) 255-8046, ext. 312/490, *www.wpafb.af.mil/museum*, 7:30 p.m.

December 12
2003 Seminar Series. Join retired U.S. Air Force test pilot Dick Rutan for dinner as he talks about his record-setting non-stop, non-refueled flight around the world in the *Voyager*, which now hangs in the National Air and Space Museum in Washington, D.C. Commemorative Air Force, American Airpower Heritage Museum, Midland International Airport, TX, (915) 567-3009, 7 p.m.

December 13
Centennial of Flight Celebration. Follow the history of Wilbur and Orville Wright's struggle to fly by viewing reproductions of their gliders and the 1903 Wright *Flyer*. Virginia Aviation Museum, Richmond International Airport, VA, (804) 236-3622, *vam.smv.org*, 10 a.m. to noon.

Santa Flight and Toy Drop. Palwaukee Municipal Airport, IL, (847) 827-0790.

December 17
First Flight Gala: Commemorating 100 Years of Powered Flight. Sponsored by the Mid-Atlantic Aviation Coalition. Tickets, $75 per person and $135 per couple, cover dinner and entertainment by the Jim Mosca Jazz Trio and the Star Dreamers swing band. Proceeds will benefit the New Jersey Aviation Hall of Fame at Teterboro. Birchwood Manor, Whippany, NJ, (908) 876-1355, gofly@nac.net, 6:30 p.m.

The Wright Path. Discover how the Wright brothers built the world's first successful airplane, the 1903 Wright *Flyer*. Explore the engineering processes used to create and improve their 1900, 1901, and 1902 gliders. Tour the museum's collection of vintage aircraft and experience interactive exhibits on the forces of flight. Virginia Aviation Museum, Richmond International Airport, VA, (804) 236-3622, 9:30 a.m., 11 a.m., 1 p.m., and 2:30 p.m.

Organizations wishing to have events published in Calendar should fax press releases two months in advance to (202) 275-1886 or mail them to Calendar, Air & Space/Smithsonian, *MRC 951, P.O. Box 37012, Washington, DC 20013-7012.*

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(Signed) David R. Kefford
General Manager

FORECAST

In the Wings...

The People and Planes of Santa Paula

First in a series of portraits of airport communities, this tour of Santa Paula Airport in California is guaranteed to make you want to fly there.

PETER MCBRIDE

Typical patrons of Santa Paula Airport: a Lockheed L-10 and Grumman AgCat.

Glacier Girl

Only a handful of airplanes reach the celebrity status of this Lockheed P-38, rescued after 50 years on ice and restored to gleaming perfection. How will this star's story end?

In Apollo's Shadow

The second Soviet Lunokhod rover traveled more than four months on the moon, but few outside Russia know of its exploits.

The Great Tiger Moth Race

De Havilland D.H. 82s swarm Maitland, Australia.

ON THE WEB SITE

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PAUL DIMARE

Solo Industries' Skypod LS

In this issue we imagine that by 2103, the personal aircraft will, despite the fits and starts of the last century, occupy every garage—or podport. How will that happen? And how will a hydrogen economy evolve? Infrastructure for air transportation? The space elevator? To learn how we got there from here, visit our Web site.

LIBRARY OF CONGRESS

The Flyer *lay damaged after the last flight on December 17, but no matter: The Wrights had achieved their goal.*

Home for Christmas

In the last issue's excerpts from *The Papers of Wilbur and Orville Wright, Volume One, 1899–1904* (McGraw-Hill, 2001), the brothers had launched "the machine" off its track, with Wilbur at the controls by dint of a coin toss. The *Flyer* rose to 15 feet and promptly sank into the sand. Orville dutifully noted the flight time as 3.5 seconds. In the excerpts below, the brothers quietly usher in the age of the airplane.

Orville Wright's Diary D, Dec. 17, 1903
At just 12 o'clock Will started on the fourth and last trip. The machine started off with its ups and downs, but by the time he had gone over three hundred feet he had it under much better control, and was traveling on a fairly even course. It proceeded in this manner till it reached a small hummock about 800 feet from the starting ways, when it began pitching again and suddenly darted into the ground. The distance over the ground was 852 feet in 59 seconds.

Telegram from Orville Wright to his father, Milton Wright, Dec. 17
Success four flights Thursday morning all against twenty-one mile wind started from level with engine power alone average speed through air thirty-one miles longest 57 seconds inform press home Christmas.

Orville's Diary D, Dec. 19
Completed packing machine and tools. About noon Jesse Ward brought telegrams from Norfolk correspondent of N.Y. *World* asking price for exclusive rights to pictures and story, and one from Editor, *Women's Home Companion*, wanting pictures. Later, Mr. Daniels brought over another batch. N.Y. *World* wanted a 600-word account telegraphed to them. *Scientific American* wanted pictures. *Century Magazine* wanted exclusive account and pictures.

Milton Wright to Carl Dienstbach, a U.S. correspondent for Illustrierte Aeronautische Mitteilungen, *Dec. 22*
Wilbur is 36, Orville 32, and they are as inseparable as twins. For years they have studied, discussed, and experimented together. Natural workmen, they have invented, constructed, and operated their gliders, and finally their "Wright Flyer," jointly, all at their own personal expense. About equal credit is due each.

Milton Wright's Diary, Dec. 25
...We dine as a family at [Orville and Wilbur's brother] Lorin's...

According to the editor of *The Papers of Wilbur and Orville Wright:* "This was the traditional family gathering the Wrights had been determined not to miss. It is entirely possible that if weather or accident had prevented the successful flights of December 17, they would have broken camp without making any further attempt in 1903."

Moments & Milestones is produced in association with the National Aeronautic Association. Visit the NAA Web site at www.naa-usa.org *or call (703) 527-0226.*

LOGBOOK

Awards

The Elder Statesman of Aviation Award was established in 1954 to honor people who have made significant contributions to aeronautics over the years. The 2003 winners: Carol B. Hallett, a pilot with 5,000 hours and a distinguished career in public and private service; David R. Hinson, a former Federal Aviation Adminstration head and a co-founder of Midway Airlines; Martin A. Knutson, long-time U-2 pilot; Joan R. Mace, chairman of the department of aviation at Ohio University; Frank G. Mitchell, a leader in aviation education and training; and *Enola Gay* pilot Paul W. Tibbets, Jr.

The Katherine and Marjorie Stinson Award for Achievement is awarded annually to a living woman for an enduring contribution, a meritorious flight, or a singular technical development in aviation, aeronautics, or aerospace. The 2003 trophy was awarded jointly to former military pilot and aircraft mechanic Mary S. Feik and Ann Wood-Kelly, also a former military pilot and airline executive.

The Cliff Henderson Award for Achievement is awarded annually to a living individual or group whose vision, leadership, or skill has made a significant contribution to the promotion of aviation or spaceflight. The 2003 award was presented to William F. Chana, aeronautical engineer and president emeritus of the San Diego Aerospace Museum, and to Jerome Lederer, founder of the Flight Safety Foundation and the former director of safety for NASA.

Nominations

Nominations will be accepted through January 10, 2004, for the Frank G. Brewer Trophy, which is awarded annually to an individual or an organization for significant contributions to aerospace education in the United States.